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The Ancient Irrigation and Water-Supply Tanks or Reservoirs of Ceylon.

By W. G. BLIGH,* M. Inst. C. E.

Irrigation, a comparatively recent science in America, has been practiced in Asia and Egypt from a time of hoary antiquity. The earliest works were probably those in Mesopotamia and in the Nile, but the knowledge of methods of direct irrigation and of storage of water must have been widely diffused for some thousands of years past in many other parts of Asia, as well as in Peru and Mexico. The methods adopted by the ancients in overcoming the practical difficulties connected with the storage and supply of water for town consumption or for the irrigation of land will naturally present features of great interest to the engineer of to-day, particularly when it is considered that they were not equipped with the scientific knowledge we now possess and were further handicapped by the almost entire absence of mechanical devices and apparatus.

In this paper it is proposed to give a sketch of some of the most ancient reservoirs constructed in the Island of Ceylon, either before the present era or in the first two centuries A. D., and to illustrate a few of the contemporary "dagobas," or pagodas in that island.

The earliest irrigation works are not very remarkable in size, having been surpassed in that respect by many works still ancient but of later date. Their great antiquity, however, adds to the zest of probing into the hidden mysteries of a dim and remote past, and bringing to light the gradual evolution of practical hydraulics.

Of ancient Ceylon it may be said that the only relics of the past are the stately dagobas consecrated to religion and the adjacent tanks which form an invariable feature in the immediate neighborhood. The once populous cities whose existence was rendered possible by these reservoirs have entirely disappeared. The only remains that testify to a prolonged residence by man are heaps of potsherds and a few upright slabs which originally formed the foundation posts of the flimsy thatched buildings, then as now, forming the bulk of the residences of the people.

The dagobas (Figs. 1 to 3, 6 and 7) some of which are larger than Cheop's pyramid, form marked features in the landscape. They rise out of a forest of trees and undergrowth into which the land for hundreds of miles around has relapsed. The embankments of the tanks are overgrown with dense forest, the haunt of wild elephants, and have remained derelict for many centuries. The population has vanished, but with the renewal of the irrigation works and the clearing of the forest these malarious solitudes will again be peopled. The Government of Ceylon has much too tardily undertaken the repair and rehabilitation of these old works, and it is from the Government engineer engaged in this work of reclamation that information on this interesting subject is rendered available.

Fig. 1. Jetavana.—300 B. C. Height, 280 Ft.

Fig. 2. Thuparama. 244 B. C.

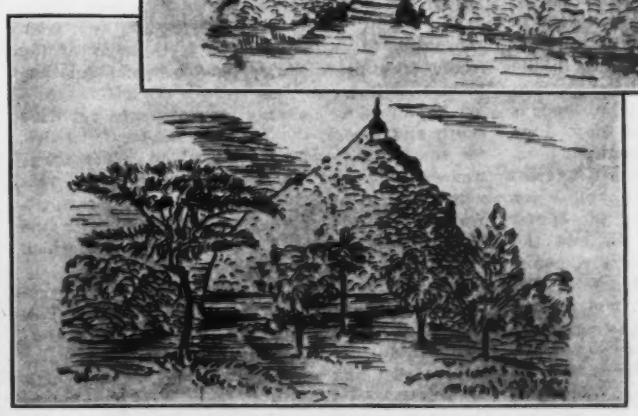

Fig. 3. Ruwanweli.—150 B. C. Height, 300 Ft.

FIGS. 1 TO 3. ANCIENT DAGOBAS OR RELIGIOUS EDIFICES AT ANURADHAPURA, ISLAND OF CEYLON.

(These Dagobas or Pagodas and the tanks or reservoirs for irrigation and domestic water-supply were always located nearby each other; see Figs. 6 and 7.)

Ceylon is a Crown Colony, too small to be properly self-supporting. Had the island been handed over to the Government of India when annexed from the Dutch 120 years ago, instead of to the tender mercies of the British Colonial Office, it is not too much to say that the rehabilitation of these irrigation works would long ago have been as much a "fait accompli" as is the case in the neighboring Presidency of Madras, where, as early as the twenties, large expenditure was incurred on irrigation works and has since continued, resulting in great increase of prosperity to the country. In Ceylon, however, nothing was done till 1875, 60 years later, and from that date on, the irrigation works have proceeded in a sure if in somewhat a leisurely manner. For the purpose of carrying out large works of this description, which will be productive of revenue in course of time, a Government having at its disposal great resources and unlimited credit in the money market is the proper medium and not a petty colony governed in the tea interests.

The great projects initiated, financed and carried out by the U. S. Reclamation Service can be cited as being corroborative of the above opinion. For such a purpose a central government like the federal government of the United States is alone in the position to be able to properly undertake such vast responsibilities.

Civilization was first introduced into Ceylon by immigrants from the Gangetic Valley, with whom trade communication by the sea route was doubtless of much earlier date. These Aryan immigrants arriving

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Fig. 4. Sketch Map of the Island of Ceylon.

about the fourth century B. C. speedily overcame the indigenous population of Vaedic origin, who were hunters and fishers, and founded a stable monarchy which eventually held sway over the whole island.

A high type of civilization was developed, the Buddhist religion, which is still in the main belief in Ceylon, and with it the Pali language, of Indo-Germanic stock, was introduced. The new settlers naturally mingled with the original Vaedic and Dravidian population, and the Sinhalese race and language is the result.

The Island of Ceylon, although in the track of the southwest monsoon and situated close to the equator, still suffers in its northern part from deficiency of rainfall, particularly at the time when rain is most required for agricultural purposes. This is due to the fact that the air current of the southwest monsoon, which brings heavy tropical rain on to the south and west coasts, is deflected upwards by the range of high mountains that forms a barrier right across the island from north west to south east. The rain clouds having deposited their superabundant moisture on the south side of this range are then carried right across the northern part of the island without precipitation, the rain being held in suspension until the Madras coasts are reached.

Thus the remarkable phenomenon is exhibited—which occurs also in Burma—of heavy cloudy monsoon weather prevailing, but the parched earth receiving no benefit from rain, until much later in the year when the northeast monsoon sets in from the Bay of Bengal. The action of this reverse current is identical with that of the southwest monsoon. Rain is precipitated in the Northern Province, while none falls south of the barrier range. This rain is too late in the season for proper agricultural purposes, consequently the artificial watering of the land is most essential during the months of May, June and July, and is eked out by occasional showers.

During the dominion of the Sinhalese Kingdom, which lasted for many centuries, their capital city was situated in the northern part of the island (at Anuradhapura; see map, Fig. 4), and the whole country must have been thickly populated and the land well cultivated. With the decadence of this ancient monarchy, due mainly to invasions by the Tamils from the south of India, the country was wasted, funds set apart for repairs of tanks failed, with the inevitable result that the irrigation works one by one fell into disrepair and were abandoned, the population also disappearing. Then the whole cultivated tract reverted into primeval forest, and is still for the most part in that state.

When the Portuguese first occupied the country, about 1580, the Sinhalese Kingdom had shrunk to a comparatively small community centered at Kandy. Neither the Portuguese nor their successors, the Dutch, ever subdued it, which was left for the British forces to accomplish about 1810.

Irrigation works, whether reservoirs or canals formed by river diversions, always require continued maintenance and repair, as they are constantly liable to accidents from abnormal cyclonic storms. Some of these storms are of such intensity that it is almost impossible to provide spillways wide enough to take the waste water. These rainbursts might not occur in a given drainage area for many years, or indeed, centuries; then at last one occurs and the reservoir embankments are overtopped and breached. If funds are not available, or a stable government in power to enforce repairs, the work becomes derelict and from apathy and want of resources is allowed to remain so.

The author of this paper was for some years in Upper Burma and had the privilege of restoring many old irrigation works in the dry zone of that country. These were erected during prosperous times by kings and governors, doubtless by corvée labor, but during the decadence of the Burmese monarchy had fallen into decay. The Government of India, shortly after the annexation of Upper Burma, undertook the rehabilitation and improvement of many of these old works, to the immense benefit of the country and to their own considerable profit. The advantage of this renewal-work lies in the fact that the great mass of the old work, if a tank or reservoir, remains practically intact. This consists in the earth embankment, which is often several miles in length. Consequently, to put the reservoir into working order generally requires but a comparatively trifling expenditure in filling up breaches and in building proper spillways and outlet sluices. Thus the old work, which costs nothing to the present generation, is utilized. For this reason this rehabilitation of old works is generally a profitable investment. In Ceylon, however, no great headway can be made in the colonization of the irrigable lands until the malarious forest is cut down and the soil broken up and put under crop. This requires time, but with proper encouragement of settlers of the right sort from India should eventually be brought to pass.

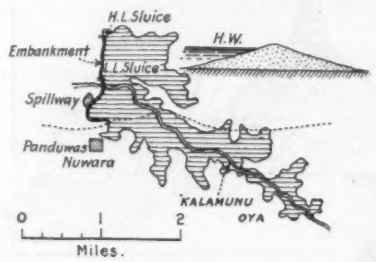

Fig. 5. Site Map of Panda Waeva Tank. Built About 350 B. C.

The recent construction of the railway from the south to Jaffna, at the north point of the island (see map, Fig. 4), which passes Anuradhapura, will greatly assist in solving this problem by affording an early market in the populous south and among the tea planters located there, for the lumber and firewood which hitherto was useless for want of transport facilities. This will form an incentive to clearing the forest, always a laborious process, particularly with the small hatchets used for felling purposes which are in such contrast to the American axe.

The first authentic records of tank construction is contained in the Mahavansa, a Pali chronicle of very ancient date, of one constructed during the reign of Panduwasa Deva, the second Sinhalese king of Ceylon, in the fourth century B. C. This tank (Fig. 5) is situated in the northwestern province near Chilaw (Fig. 4) and is termed after its founder the Pandawaeva Deva, or Panda's tank. Close adjoining are the remains of a strongly fortified citadel with walls brick-lined 40 ft. thick, enclosing an area 1,000 ft. square. The moat outside the wall is traceable, being even now 7 ft. deep. This cita is believed to be of much later date than the nk, and was for the protection of the adjacen ity of Panduwas Nuwara, all trace of whic as completely disappeared. ("Nuwara" in Pa nd Sinhalese means city, and "Waeva," nk. "Kulam" is the Tamil equivalent of Waeva ya means river.)

The area of this reservoir, which was us for water-supply to the city monasteries, as w as for irrigation, was 1,360 acres, or about 2 s ni.

Fig. 6. Site of the Ancient City of Anuradhapura, Showing Location of Abhaya, Tissa and Nuwara Waevas, or Tanks, and Various Dagobas.

and its available capacity about 10,000 acre-feet, but double that amount if replenished.

The works connected with these ancient tanks are of exactly the same description with which we are familiar in the present year of grace in the United States.

Firstly, a carefully constructed homogenous embankment of earth with suitable side slopes—often, strange to say, 3 to 1 fore and 2 to 1 rear slopes, as is now the practice; secondly, a flood escape consisting of a waste weir built across a river gorge, supplemented by spillways over suitable rock benches; and thirdly, the outlet sluices.

It is these outlet sluices that are of the greatest interest, as it has often been a puzzle to conceive how the regulation of water through the sluice culverts at great depths could have been effected, in the complete absence of screw gear or lifting apparatus. The principle of the screw, as applied to lifting weights, was not known in those remote times. The pulley, the inclined plane and the lever were the three mechanical powers with which they were acquainted. Drawings of several of these old sluices will be given from which the reader will be enabled to judge pretty closely what were the means used. The method adopted consisted mainly of a valve tower or pit with inlet and outlet sluices, which latter could both be closed by draw gates and thus the pressure reduced by one-half.

The valve tower was first invented and used in Europe in the 19th century, but there is nothing

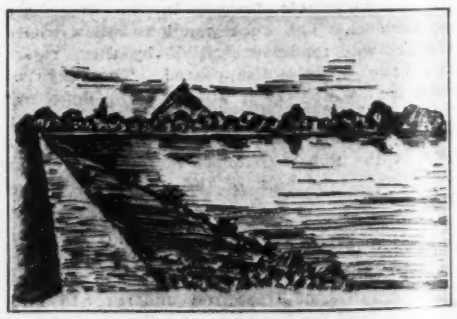

Fig. 7. View of Abhaya Waeva or Tank, Anuradhapura, Ceylon, with Ruwanweli Dagoba in background.

Fig. 8. King Duttha-Gamini: 161-137 B. C.
(From an ancient wooden statue, cased in plaster.)

new under the sun, and as gunpowder, the art of printing and the compass were used in Asia centuries before they become known to Western civilization, so here we find the valve pit in common use 2,300 years ago.

The accompanying map (Fig. 5) is a site of the Panda Waewa Tank. The date of its construction (and that of other tanks which are now known by different names to what they originally bore in the Mahawausa) is easily ascertainable from the size of the bricks and from comparison of them with those in certain dagobas, the date of whose construction is an archaeological certainty. The arts of stone cutting and brick making were doubtless well advanced before the erection of the earliest dagobas in the third and fourth century B. C. No mere learners could have erected these works, nor carved the inscriptions.

The embankment of the Panda Waeva Tank is 8,400 ft. long and 22 ft. high above the sill of the low-level sluice. It is alined so as to abut on to a rock which rises above the valley. This ledge of rock was utilized as a wasteway or spillway, 250 ft. wide, the level being 9 ft. below that of the embankment and 13 ft. above the sluice sill; the embankment continues the other side of the rocky ledge, taking a sharp turn to the right in order to keep to the higher ground. The sides of the embankment were sloped down to the level of the spillway and protected with rip-rap, just as would be done now.

This escape proved sufficient for many centuries, for the tank lasted till 1810, when the embankment was breached by being overtopped.

In modern storage reservoirs it is a not uncommon practice to furnish the waste weir with collapsible crest shutters or automatic drop gates. By this means the capacity of the reservoir is increased by several feet and the full supply and flood levels are rendered coincident. Thus the inevitable waste of material in the embankment arising from the crest having to be raised well above the highest flood is avoided, as this extra weatherboard space can be included in the capacity of the tank. The ancients were well aware of this fact and the means they adopted to effect this object was to set upright stone posts in mortise holes in the rock of the spillway, or in the masonry of a waste weir, against which a temporary barrier of planks and mud was raised, the whole of which would be carried away by the first heavy freshet in the river—to be again raised when the flood has subsided.

The Panda Waeva Tank has been repaired and put in working order but quite recently, having been allowed to remain derelict for not far short of a century, when an expenditure of a few hundred dollars would have put it right.

The next oldest tank is Abhaya Waeva (Fig. 7), now known as Basanuk Kulam. This is situated at Anuradhapura, the old capital city of Ceylon, now a small village but a show place from the many interesting ruins of dagobas and monasteries which rise on all sides out of the trees of the jungle. The tank, which is quite a small one, is shown in the map of Anaradhapura (Fig. 6). The accompanying pen and ink sketch (Fig. 7) shows the tank, which was repaired in 1874, with the peculiar lop-sided Ruwanweli Dagoba (Fig. 3) in the distance. The plan of the tank shows the embankment curved round so as to approach as nearly to the city as possible. In doing so it crosses ground lower than the outer sluice sill (Fig. 6), and then turns sharply up-stream. The embankment is 1⅛ miles long. Its crest was originally 28 ft. above the sill of the outlet sluice; it is now 22 ft. The water slope is protected by a layer of riprap. The area was originally 330 acres and capacity 3,000 acre-feet. It was essentially for city water-supply. The water was run out into ponds, or bathing tanks, or into square wells, underground, whence it was dipped up by the women of the city—as is done in many Eastern cities to this day.

The sluice was of the usual rectangular type, provided with a "bisokotwa," or valve pit, to be described later. The spillway was through a natural depression at the end of the embankment, which is now 4 ft. lower than originally. The Abhaya Waeva was built by King Pandukabhaya, grandson of Panduwasa Deva, and is mentioned in the "Chronicles."

The adjoining Tissa Waeva (400 acres) (Fig. 6) was built in the third century B. C. It is U-shaped—an alinement of the embankment rendered necessary wherever the ground is on a gradual slope and the reservoir is shallow. It has two sluices and two escapes. It is close to the Miriswaeti Dagoba, which was built at a later date by King Duttha Gamini, whose portrait is shown in Fig. 8, photographed from an ancient wooden statue recently exhibited in excellent preservation.

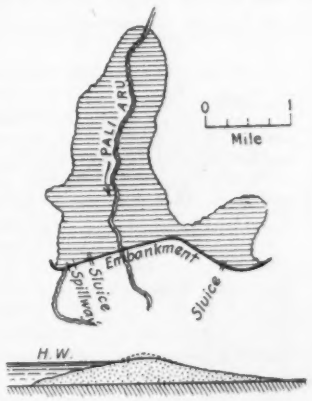

Fig. 9. Plan of Vavunik Kulam Embankment and Tank. 160 B.C.

The next oldest tank is the Vavanik Kulam (Fig. 9), built about 160 B. C. This is the earliest purely irrigation tank and is situated in the Northern Province. The embankment is carried straight across the valley of the Pali River and is 2½ miles long. A total of 2,000 acres is flooded and the capacity of the tank is 14,000 acre-feet. The embankment has been badly breached in several places, owing to exceptionally heavy floods, and it is now covered with dense jungle, having lain derelict for several centuries. The embankment has very flat slopes, being 4.8 and 4.6 to 1 on either side. Two large flood escapes of adequate waterway for all ordinary occasions were provided and were probably found sufficient for several centuries. This part of the island is subject to severe rain bursts, 35 ins. having been reported on one occasion in 28 hrs. The run-off from a cyclonic storm like this must have overtopped the embankment and caused its destruction, and as there were probably no funds available to enable it to be made good, or authority to enforce its repair, it was left derelict and the cultivators dependent on the tank for a livelihood were forced to desert the neighborhood.

The next tank, the Pavat Kulam (Fig. 10), cannot be traced in the Chronicles, so that its exact date is a matter of speculation. It is, however, a work of the 3d and 2d centuries B. C. The alinement is most judicious. It embraces two valleys and is divided into three parts, separated by natural knolls. The embankment has a top of 10 ft. and side slopes 3.2 and 2.6 to 1, respectively. This is the earliest example of a steeper inclination having been adopted for the rear slope of the bank, as is universally the practice at the present day. Surplus water was disposed of by two spillways, 100 ft. and 25 ft. wide, respectively, over natural rocky ground, and by a waste weir 125 ft. long, built in the line of the embankment. This was probably constructed at some later date over the site of a breach in the bank.

The weir is 125 ft. long and about 15 ft. high. It is provided with a floor 60 ft. wide, built of carefully packed stone of large size.

The connection with the embankment was formed by the end slopes revetted with carefully laid large stones. This waste weir is provided with the ancient equivalent to the collapsible weir shutters or automatic drop-gates which are used in many modern reservoirs; that is, upright slabs, fixed in pairs at irregular intervals on the crest. The inside posts were about 2 ft. high and the outer, separated from them by a space of a few inches, were 5 to 6 ft. above the weir crest. This was evidently used for the insertion of planks to form a temporary dam and thus effect what is aimed at by reservoir engineers at this day, viz.: to make the full supply level of the tank if possible coincident with that of the highest flood level.

Fig. 10. Plan of Pavat Kulam Embankment and Tank.

The crest of the embankment was only 8 ft. above that of the waste weir. This was doubtless insufficient. The capacity of the tank at weir crest and spillway level was 18,000 acre-feet. If the level were artificially raised 3 ft. the capacity would amount to 25,000 acre-feet.

The wasteway channel below the weir was

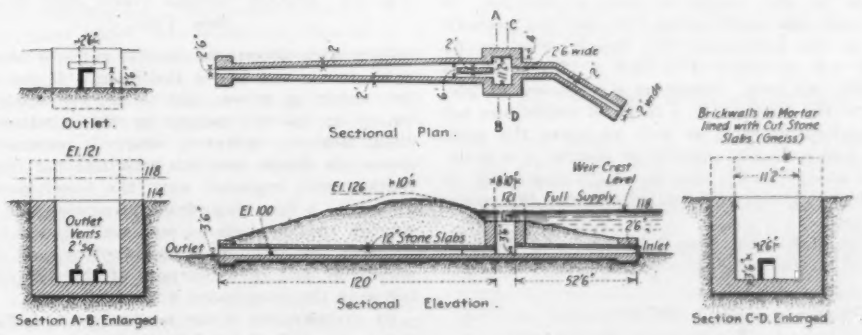

FIG. 11. DETAILS OF SOUTH LOW-LEVEL SLUICE PAVAT KULAM TANK—BUILT ABOUT 250 B. C.

spanned by a bridge formed of stone posts and cross girders which were either overlaid by timber planking or by longitudinal stone slabs. The remains of this bridge are still in existence.

This tank was provided with no less than four sluices, in addition to a high-level culvert underneath the floor of the waste weir. The irrigation it effected must have been considerable, as the probability is that the tank was replenished by freshets in the river during the irrigation season. The southern and lowest sluice is shown in Fig. 11. This plan was drawn up by the engineer who was in charge of the reconstruction of the sluice. This particular sluice is of special archaeological interest from the unbroken state of the bricks used in the sluice well or pit, and the fact that their size was that of the 3d century B. C., which shows that a considerable portion, at least, of the sluice has lasted for 2,300 years.

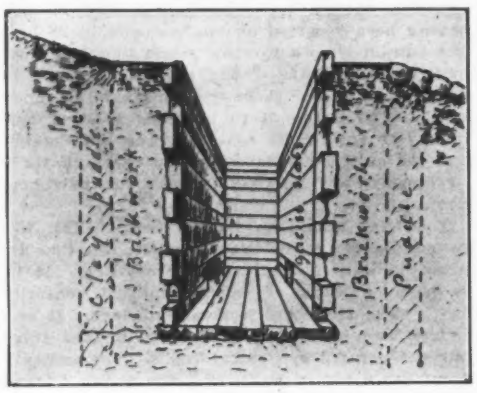

Fig. 12. Low-Level Sluice.

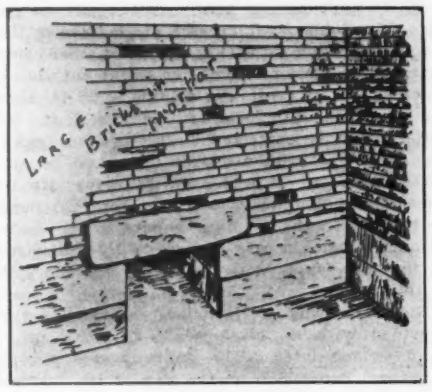

Fig. 13. High-Level Sluice.

FIGS. 12 AND 13. INTERIORS OF VALVE PITS OR "BISKOTWAS," PAVAT KULAM TANK.

As in all later sluices, the work consisted of three parts: (1) a rectangular open well or pit built at the point where the permanent supply level, or that of the crest of the waste weir meets the inner slope of the embankment; (2) an inlet culvert through which water was admitted into the valve pit; (3) a discharging culvert from the well to the foot of the bank.

The Biskotwa or valve pit was introduced primarily as a means of compassing the manipulation of the sluice-gates which latter were attached to the outlet sluice alone. In course of time, when greater depths had to be dealt with, a further development took place in the control of the inlet valve as well. By this means the admission of water into the valve pit in addition to that passing out of it was rendered subject to regulation. It thus became possible to reduce the acting head of water by one-half, the total head being divided between the inlet and the outlet vents. In the Pavat Kulam sluice, Fig. 11, the inlet vent is single, 3 ft. 6 ins. deep by 2 ft. 6 ins. wide, having a superficial area of 8.75 sq. ft. This is more than double that of one of the two vents with which the outlet culvert head is provided. This fact, together with the moderate depth of the tank (about 20 ft.) induces the belief that only the outlet sluices in this tank were provided with gates. The pressure on one of these will be $H \times A \times w$, in which H is the head, measured to the center of the vent, A its area and w the unit weight of water or 62.5 lbs. In this case, the vents being 2 ft. sq., the pressure due to the permanent full supply level or El. 118.0 will be $17 \times 4 \times 62.5 = 4{,}250$ lbs., or roughly two tons. Assuming a coefficient of friction of the gate at .5, a force of about one ton is required to raise as well as lower the gate. This was probably effected by means of a lever, like a pump handle; that is, of the first order, in which the fulcrum is situated between the power and weight.

If the short arm were 2 ft. long and the long arm 16 ft., the mechanical advantage would be 8, and the power $\frac{2125}{8} = 266$ lbs.

If the gate has only to be lifted, this power could be mostly provided for by a counterweight, as is done in the balance poles used for bucket irrigation from Pharoah's time to the present day; or if not, six men could easily provide the power.

The same lever could be used for forcing the gate down, but this would involve hauling the long arm upwards by means of ropes over elevated pulleys, and the counterweight would have to be removed. The best system of leverage for forcing the gate down would be a lever of the second order, in which the end of the lever beam is fixed as a fulcrum by being held down by posts built into the masonry of the valve pit. The power is applied downwards in the same way as before, at the end of the lever. Most of this work could also be done by a counterweight. The application of two different levers would, however, be productive of delay and difficulty. This induces the belief that the gates were lowered by impact. The writer has often seen this done in the older regulating gates on Indian canals, which were sometimes double gates working in one groove, one above the other. If the lower one stuck, as it was apt to do, the upper was raised to its full height by the windlass and then suddenly released, when it rammed the lower one down; and this primitive but effective method was repeated until the lower gate got "home." A few blows from the monkey of a small ringing engine, such as was well known to the ancients, on the top of the shutter post would effectively and easily dispose of the difficulty of lowering the gate under a head of water.

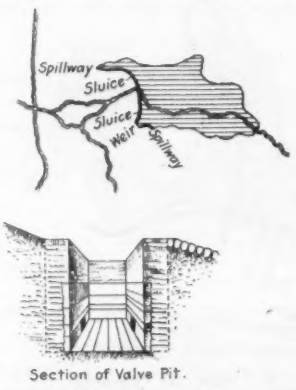

Fig. 14. Plan of Sangili—Kanadara Embankment and Tank and Sectional View of Valve Pit. 250 B. C.

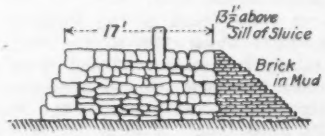

Fig. 15. Section Through Waste Weir of Kanadara Tank.

By examination of the section on A A Fig. 16 (post) it can be judged that the arrangement of closing the vents was probably as follows: Four upright posts, say 1 ft. sq., were erected between and just outside the two vents. These uprights were rabbetted at the inner corners, this provided grooves between the posts and the face of the wall, in these grooves the draw gates worked, their faces bearing against the smooth stone wall of the valve pit, or else wooden linings could easily have been provided. The draw gate or shutter may have been of stone. It was probably let into a heavy upright square post which reached up to the top of the well, the end of which the lifting rope could be attached, while its butt end presented a surface for the blows from the driving monkey. The upright frame posts must have been wedged across and side ways to the walls of the valve pit so as to be immovably fixed without the necessity of mortise holes, which were not provided. The above is believed to be a reasonable surmise as to how the sluice gates were operated under considerable pressure. The biskotwas once invented were found so indispensable that no tank sluice was subsequently constructed without them, thus anticipating western invention by 2,200 years. They were generally rectangular in plan and sometimes square, the longer sides facing the vent holes.

In Fig. 11 the general details are clearly shown, but a few remarks may not be out of place.

The inlet culvert here has a peculiar bend, not reproduced in other sluices. This must be due to reconstruction after an accident to the lower half of the culvert.

The outlet sluice, near the valve pit, is split into two passages each 2 ft. sq., being widened out for the purpose. This construction is peculiar to this tank. In both inlet and outlet sluices the roof slopes upwards towards the outlet where the section is deeper as well as wider than at the commencement. This very remarkable refinement in design is believed to have been purposely designed in order to reduce the pressure in the interior of the culverts. It seems to occur in no other instance. The culverts are roofed in by stone slabs of the thickness shown in the figure. These are smooth worked on both face and ends and very carefully fitted together.

The walls of the culverts are of good brickwork in lime mortar. Those of the valve pits are also of brickwork, but have a thick backing of puddle or rammed clay and are lined inside with truly dressed smooth stone slabs. A perspective explanatory section is given in Figs. 12 and 13. The latter sketch shows one of the vents of the high-level sluice, and was made before the work was demolished, as was unfortunately the case. However, without this reconstruction the plans of the ancient work would not have come to light. This accounts for the sluices in the previous two examples being passed over without comment, as they were not interfered with.

In Fig. 11 the original height of the valve pit was at least El. 118.0, or weir-crest level, if not raised to 121, or 3 ft. higher.

The position of the valve pit seems invariably to be fixed at the intersection of a horizontal line at weir-crest level, or permanent full-supply level, with the inner slope of the embankment.

Fig. 14 is a sketch site plan of the Sangili Kanadara Waewa. This is a good example of a medium-sized irrigation tank. Its date, from the bricks used in construction, is placed at the 3d century B. C. The very flat slopes of the embankment, nearly 5 to 6, also indicate a very early date. This work is provided with two flood escapes, or spillways, and one waste weir. The former are 450 and 80 ft. wide, respectively, and the waste weir, of which a section is given in Fig. 15, is 270 ft. in length. This is believed to be of somewhat later date. Smaller bricks, observed in the sluices and their valve pits, prove that the last restoration done to this tank was in the 10th or 11th century of the present era. The weir crest is 13½ ft. above the sills of the lowest sluices and the top of the bank is only 4 ft. higher. It must have been higher originally. The weir is provided with stone posts, 3 ft. high, in order to enable the reservoir level to be temporarily raised. The capacity of the tank at 2 ft. above permanent weir crest is 6,300 acre-

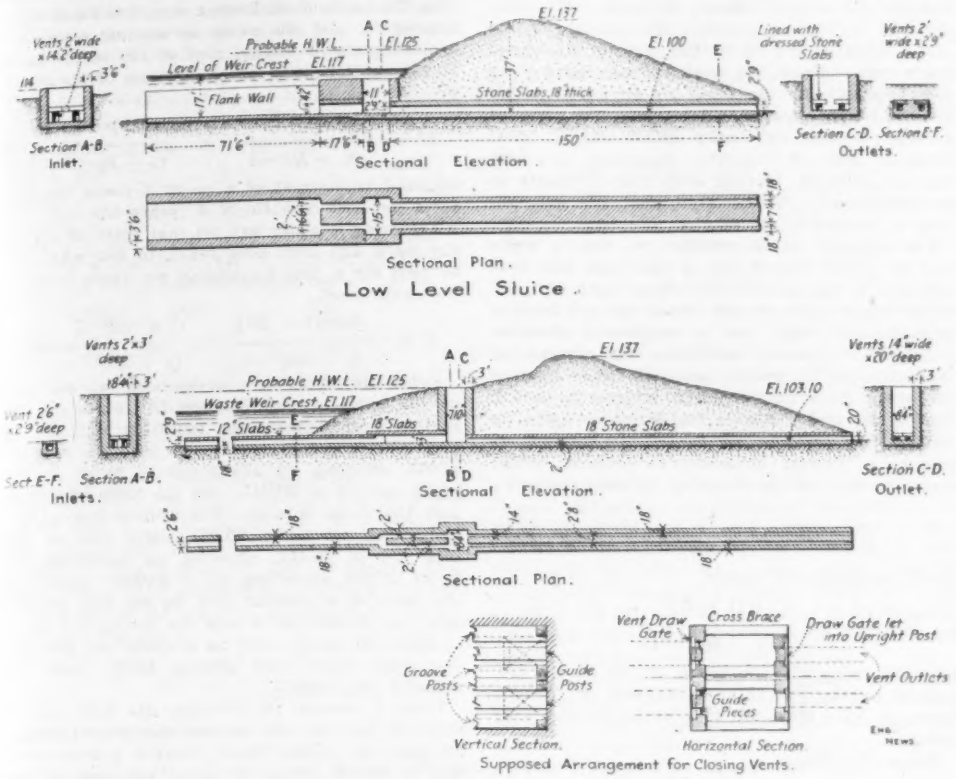

FIG. 16. NUWARA WAEWA EMBANKMENT AND SLUICES—ABOUT 80 B. C.

feet. It is probably also replenished during the irrigating season. A view is given of the biskotwa (Fig. 14). The peculiar overlapping of the face stones in the weir in Fig. 15 is worthy of attention.

This article would be too lengthy if notice were taken of the ancient southern reservoirs of which there are several of importance, but no plans of them other than a map are available, or of the Batalogoda tank in the Northern Province near which was situated one of the "Lost Cities," whose site is still known as "Purana Nuwara," or the "Old City." It

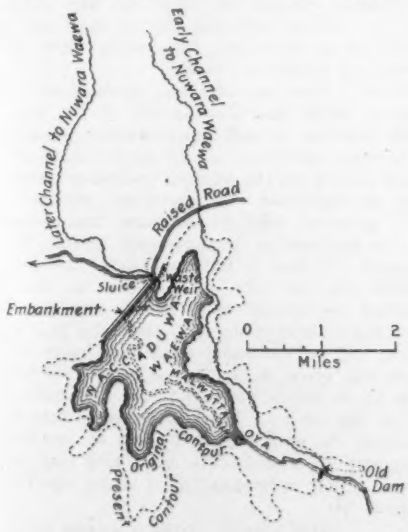

Fig. 17. Site Plan of Naccaduwa Tank.

will therefore conclude with notices of Nuwara Waeva and Naccaduwa tanks near Anuradhapura. The former, shown on the map, Fig. 4, is close to the old capital city of Anuradhapura but on the other side of the Malwatta Oya River. This tank, as well as the Abhaya and Tissa waevas, already mentioned, has been put into thorough repair by the Ceylon Government and would be capable of effecting an immense area of irrigation, were the Kala Waeva reservoir (Fig. 4) some 30 miles distant, in working order up to its original capacity. This immense tank has an embankment six miles long and some 60 ft. high. It is supposed to have impounded from 30 to 40 ft. of water and was used as a reservoir to replenish the Naccaduwa and Nuwara tanks, by means of the channel of the Malwatta Oya, which latter river also effected direct irrigation from diversion channels excavated below the two stone weirs, shown in Figs. 6 and 7.

It is probably to the early part of the first century B. C. that the construction of Nuwara Waeva, "The City Tank," the last of the early reservoirs of Anuradhapura, must be assigned. The embankment spans a shallow flat valley and is U-shaped in plan. It is provided with two sluices, a high-level and low-level, details of which are given in Fig. 16. In both sluices the inlet is provided with two vents. This seems to show unmistakably that by this time the advantage of having the inlet vents under control as well as the outlet was known. The inlet vents are still made larger than the outlet. The reason for this is difficult to determine, unless the object were to enable the interior to be inspected and obstacles removed.

In the low-level sluice, Fig. 16, the outer wall of the valve pit is 7 ft. thick, which would be an unnecessary width, unless space was required for lifting apparatus. The inlet culvert is quite short, the continuation being an open channel provided with a floor and flank walls. It is quite possible that in this sluice the inlet vent draw gates or valves were placed *outside* the dividing wall instead of inside the valve pit. This is the place where they would be situated in a modern work and where the screw-lifting draw gates are now placed in the reconstructed sluice. If so, this is an innovation in the right direction. The valve pit was probably built up to Elev. 125, the same as the high-level sluice, if not higher. In fact, it must have been so raised to prevent submergence.

This tank has no waste weir but a spillway in a depression between two rocky knolls.

The high-level sluice, Fig. 16, must have had the regulation for inlet and outlet vents both inside the valve pit. Side posts having rabbets taken out at each corner will provide a shoulder or groove table against which the inlet gate would work and which would keep the outlet draw gate in position. They would be strutted across as well as to the sides of the pit. As already explained, the draw gate would be let into, and fastened to an upright post by which it could be pulled up or driven down. This is shown in Fig. 16a, which is a half section and half elevation from inside the valve pit showing the supposed arrangement.

The capacity of the tank at the higher level of Elev. 125.0 is 35,000 acre-feet. The supply was supplemented from the Malwatta Oya, which was dammed higher up, as shown in Fig. 17, which is a map of the adjoining Naccaduwa tank. This weir was 33 ft. wide, 8 ft. high and 160 ft. long, and from above it a channel 40 ft. wide with a bed slope of 1 in 5,000 was cut into a small stream which flowed into the reservoir 5½ miles from the dam. This supply channel, which had no head regulator, was furnished with an escape consisting of a lateral spill over rocky ground, which relieved the channel when too much water entered the head. All these arrangements, even to the bed slope, are quite in accordance with modern works and evince a high knowledge of the science of irrigation on the part of these early engineers.

The flanks of the escape as well as those of the head of the channel were furnished with carefully revetted slopes.

There are remains of several stone post bridges over irrigation channels and spillways denoting the former populous state of the country. This dam and its diversion channel were centuries later supplanted by another work on the same river, namely: the Naccaduwa Waewa which lies above Nuwara Waeva and is a later supplementary work. From the site plan, Fig. 17, it will be seen that the Malwatta Oya has again been dammed by an embankment at a bend in the river and the valley closed up. Near the river bank a waste weir was built in an artificial spillway. A section of this weir is given in Fig. 18. Its crest is 14½ ft. above the sill of the sluice and its depth is about 13 ft. It does not span the actual river bed. Details of the biskotwa and inlet and outlet vents are also given in Fig. 18. A further advance is made over the Nawara Waeva low-level sluice, in adopting a narrower partition wall, the outer wall of the valve pit only having been made somewhat wider than the others were. In all probability regula-

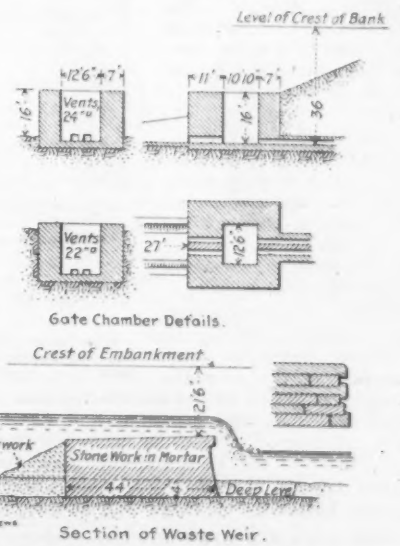

Fig. 18. Details of Naccaduwa Tank.

tion of the inlet sluices was effected *outside* this divide wall. The usual inlet culvert is abandoned and an open approach channel, protected by two battered walls of dry masonry—substituted, which has a very modern look. As in Fig. 13, only the lowest 3 ft. in the valve pit was lined with dressed stone, the rest being of brickwork. This points to the conclusion previously arrived at, that the smooth stone lining was primarily for the draw gates to work against. Part of the flood water passing over the weir rejoined the weir at a lower level and part was intercepted and cov-

ered by a channel 50 ft. wide into Nuwara Waewa.

The capacity of the tank was originally 12,000 acre-feet. As restored, it is 35,000 acre-feet. Its primary object was not so much the storage of water as diversion of part of the flood water of the Malwatta Oya into Nuwara Waewa, the old dam having failed. Naccaduwa Tank, termed Mahadaragella Waeva in the Mahavansa Chronicles, was built by Mad a sena 277-304 A. B. The peculiar overlapping of lower courses of stone beyond the upper ones (as in Fig. 15) is again a constructional feature in the weir. Hammer-headed headers were also occasionally introduced, as shown in Fig. 18.

Many of the numerous readers of Engineering News must be interested in reservoirs, and I would suggest that opinions be expressed on these old designs. Perhaps further explanations may be forthcoming of the peculiarities of portions of the works and the object sought to be arrived at by the unknown designers elucidated. The writer himself has inspected all the works clustered around Anuradhapura, as well as the great Kalawaaeve Tank (which is not included in the list) some 13 years ago.

The sketches and plans of works reproduced in this article are derived from "Ancient Ceylon" (Lusac & Co., Publishers, London, England), a work by Mr. H. Parker, formerly an engineer in the Ceylon Public Works Service. Ceylon is well worthy of a visit. It is easily accessible, being on the main sea route to the further East, all ships coaling at Colombo.

An Economic Comparison of Railway Ties of Different Materials.*

By NEIL N. CAMPBELL.†

The great question that confronts the railroad man and the engineer of to-day is: Which is the most economical kind of tie for track work? To answer this question satisfactorily and finally, one must consider all the factors on which the value depends, but this (in many cases) is impossible. The factor of life is probably the most uncertain of all, and the hardest to obtain. This life is influenced by the climate, weather, use, protection, etc., and each of these in turn is variable. It is not the purpose of this article to arrive at any final results which would apply in any locality or time, but merely to show methods of comparison and the results obtained by their use.

The principal elements that must always be considered in determining the relative merits of different materials used as railway ties are: (1) first cost; which should include the cost in forest, the freightage, handling and distributing, and the cost of placing the tie in the track; (2) life, that is, the time elapsing from the date when the tie is laid to the time when it becomes necessary to renew it; (3) cost of renewals; (4) rate of interest on money; (5) maintenance, or cost of repairs; (6) salvage, or the scrap value of the tie at the close of its life of usefulness. Since the cost of maintenance on ties is practically the same for all kinds, it will be omitted in this consideration. The item of salvage is also extremely small and in most cases is zero or negative; therefore, this also will be omitted, leaving only four elements to be considered: (1) the first cost; (2) life; (3) cost of renewals; (4) rate of interest.

For example, let us consider two ties; a white oak tie which cost 68 cts. in the track and lasts nine years, and a pine tie which costs 61.5 cts. in the track and lasts six years. On the basis of capitalization, that tie is considered cheapest which under present conditions will require the least amount to install, and the least amount to be set aside at compound interest to reproduce it for ever. The capitalization is made up of: (a) the first cost = C, (b) the amount at compound interest necessary to produce in interest during the life of the tie its first cost = C'.

$$C^1 = \frac{C}{(1+R)^n - 1}$$

Total capitalization equals

$$C + C^1 = \frac{C(1+R)^n}{(1+R)^n - 1} \qquad (1)$$

in which n equals the years of life of the tie, and R equals the rate of interest on money, taken as 4%. Then the total capitalization is as follows:

White Oak Tie.

$$\frac{0.68\ (1+.04)^9}{(1+.04)^9 - 1} = \$2.286$$

Pine Tie.

$$\frac{0.615\ (1+.04)^6}{(1+.04)^6 - 1} = \$2.933$$

On the basis of annual cost that tie is considered cheapest which under present conditions shows the least annual cost. The annual cost being made up of: (a) the interest on first cost = $I = CR$; (b) the amount that must be set aside annually at compound interest to provide for renewal at the expiration of the life of the tie =

$$A = \frac{CR}{(1+R)^n - 1}$$

Total annual cost =

$$I + A = \frac{CR(1+R)^n}{(1+R)^n - 1} \qquad (2)$$

The annual cost of white oak tie =

$$\frac{0.68 \times .04\ (1+.04)^9}{(1+.04)^9 - 1} = \$0.091$$

The annual cost of pine tie =

$$\frac{0.615 \times 0.04\ (1+.04)^6}{(1+.04)^6 - 1} = \$0.117$$

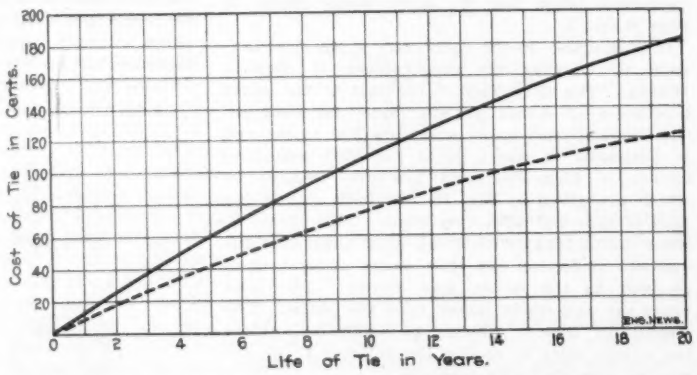

DIAGRAM OF EQUIVALENT COST OF TIES OF DIFFERENT LENGTH OF LIFE.

(The dotted curve shows the cost on the basis of a white-oak tie costing 68 cts. and lasting 9 years; interest at 4%. The solid curve shows the cost on the basis of a tie which costs $1 in the track and lasts 9 years; interest at 4%.

On the basis of equivalent cost, one tie is considered to cost the same as another when the capitalization or annual cost of the one is equal to the capitalization or annual cost of the other, or

$$C^1 = \frac{C(1+R)^n}{(1+R)^n - 1} \times \frac{(1+R)^{n1} - 1}{(1+R)^{n1}} \qquad (3)$$

where C is the cost of a tie of N years life and C' is the cost of a tie of N' years life.

Assuming a white oak tie that costs 68 cts. in the track and lasts nine years, to find what can be paid for a pine tie lasting six years to show the same merit,

$$C^1 = \frac{0.68\ (1+.04)^9}{(1+.04)^9 - 1} \times \frac{(1+.04)^6 - 1}{(1+.04)^6} = \$.479$$

From the foregoing consideration, we see that on the basis of capitalization the white oak tie is the more economical, requiring only $2.286 total capitalization, while the pine tie requires $2.933, showing an advantage in favor of the white oak tie of $0.647. On the basis of annual cost the same is true. The annual cost of the white oak tie being $0.091 while that of the pine tie is $0.117, showing an advantage in favor of the white oak tie of $0.026. Again, on the basis of equivalent cost we see that we can only pay $0.479 for a pine tie lasting six years to show the same merit as a white oak tie lasting nine years, and costing $0.68, while we actually pay $0.615.

Table I. shows the average life and cost in track of the ties used on representative railways all over the United States, having a total mileage of 62,309 miles. It gives the kind of ties used, their average life, their average cost in track, together with the comparative value of each on the basis of capitalization, annual cost, and equivalent cost, using as a basis for comparison a live white oak tie costing $0.68 in the track and lasting nine years. Ties which show an average life of a fraction of a year in the computations were considered to have a life represented by the nearest whole number of years.

The figures in last column of this table indicate the order of merit of the ties as shown by their capitalization and annual cost, regardless of the kind of timber used or whether they were treated or untreated.

The lower line in the accompanying diagram represents graphically what we can afford to pay for ties of different life to show the same merit as a white-oak tie costing $0.68 in the track and lasting 9 years.

Table 1 does not take into account the necessity of using tie-plates on any of the ties, but with increase in traffic and heavier rolling stock it becomes necessary to use tie-plates on all soft wood ties on curves whether treated or untreated, and on hardwood ties which are treated. The best practice also recommends that tie-plates should be used on all soft wood treated ties on tangent. If this is not done it is impossible to obtain the full life of the ties, as they fail through mechanical wear before they lose their usefulness through decay. Assuming that a live white oak tie will resist mechanical wear as long as it can resist decay, let us compare with it a pine tie on which we have to use a tie-plate. The white oak tie with life of 9 years to cost $0.68; the pine tie with life of 6 years to cost $0.615; tie-plates to cost 14 cts. each and last for 20 years. Total capitalization of white oak tie (by formula 1):

$$= \frac{C(1+R)^n}{(1+R)^n - 1} = \frac{0.68\ (1+.04)^9}{(1+.04)^9 - 1} = \$2.286$$

Total capitalization of pine tie equals:

(a) First cost in track = C, = cost of pine tie to be renewed every 6 years, 0.615; cost of two tie-plates to be renewed every 20 years, 0.280; total, $0.895.

(b) The amount at compound interest necessary to produce in interest during the life of the tie its first cost;

$$= C_1 = \frac{C - T}{(1+R)^n - 1}$$

*This article is a portion of a thesis prepared by the author for the University of Illinois, but he has made some changes and additions to the original form. He informs us that the substance for formulas (1), (2) and (3) was used by Mr. S. S. Roberts (until recently Professor of Railway Civil Engineering) in a class on the economic theory of railway location. Mr. Campbell obtained the idea in this way, but worked out the formulas in greater detail and introduced the other formulas which are given in his paper. A paper on the same subject (but treated in a somewhat different manner) by Mr. W. C. Cushing, M. Am. Soc. C. E., Chief Engineer of Maintenance of Way, Pennsylvania Lines (Southwest System), forms an appendix to the 1908 report of the Tie Committee of the American Railway Engineering and Maintenance of Way Association, and his conclusions were given in Engineering News of Aug. 2, 1906. The first of these conclusions is that with white oak ties at 70 cts., it will pay to take inferior woods at a price not over 50 cts., treat them by the zinc-chloride or zinc-tannin process, and use them without tie-plates, providing that a life of ten years is obtained.—Ed.

†Care of Anderson & Russell, Lake Forest, Ill.

(c) The amount at compound interest necessary to produce in interest during the life of the tie-plates their first cost

$$= C_2 = \frac{T}{(1+R)^{n1}-1}$$

Total capitalization $= C + C_1 + C_2 =$

$$\frac{C(1+R)^n}{(1+R)^n-1} - \frac{T}{(1+R)^n-1} + \frac{T}{(1+R)^{n1}-1}$$

where T = cost of tie-plates which last N^1 years, N = life of tie, R = rate of interest on money. Then total capitalization of pine tie =

$$\frac{0.895(1+.04)^6}{(1+.04)^6-1} - \frac{28}{(1+.04)^6-1} + \frac{28}{(1+.04)^{20}-1} = \$3.448$$

The annual cost of the live white oak tie (by formula 2) =

$$\frac{CR(1+R)^n}{(1+R)^n-1} = \frac{0.68\times.04(1+.04)^9}{(1+.04)^9-1} = \$0.091$$

The annual cost of the pine tie equals, (a) the interest on first cost $= CR$, (b) the amount that must be set aside annually at compound interest to provide for the renewal of the tie at the expiration of its life =

$$A = \frac{R(C-T)}{(1+R)^n-1}$$

(c) The amount that must be set aside annually at compound interest to provide for the renewal of the tie-plates at the expiration of their life is

$$A_1 = \frac{RT}{(1+R)^{n1}-1}$$

Then total annual cost $= I + A + A_1 =$

$$\frac{CR(1+R)^n}{(1+R)^n-1} - \frac{TR}{(1+R)^n-1} + \frac{TR}{(1+R)^{n1}-1}$$

$$= \frac{0.895\times.04(1+.04)^6}{(1+.04)^6-1} - \frac{.28\times.04}{(1+.04)^6-1} + \frac{.28\times.04}{(1+.04)^{20}-1} = 0.138$$

From these examples we see that the white oak tie shows considerable advantage over the pine tie, requiring only $2.286 capitalization, while the pine tie with a tie-plate requires $3.448. A similar advantage is shown when the two are considered on the basis of annual cost. The annual cost of the white oak tie being $0.091, against $0.138 for the pine tie.

Table II shows the same data as in Table I, except that in the comparison of the ties on the basis of capitalization and annual cost it was considered necessary to use tie-plates on all ties excepting the white oak, other oaks, chestnut, gum, beech, birch and maple, which are untreated. In the case of these ties it was considered that they would resist mechanical wear as long as they can resist decay.

The figures in the last column of this table also represent the ties in their order of merit, as shown by their capitalization and annual cost. By comparing these figures with those in the last column of Table I we see the effect upon the capitalization and annual cost of the tie, caused by the use of tie-plates. In Table I, the white oak tie is No. 25 in order of merit, while in Table II it jumps to No. 7. Again, the untreated pine tie drops from No. 29 in Table I to No. 31 in Table II, while the chestnut jumps from No. 24 to No. 3. These figures show also the relative merit of ties of the same kind which are treated with different treatments. For example, in Table I the creosoted pine tie holds 3rd place, the pine tie treated with zinc chloride holds the 28th and the untreated pine tie holds the 29th place. In case of the creosoted gum tie we find it occupies 4th place, the same tie treated with Rueping process drops to the 7th place, while the untreated gum falls to the 31st place.

The upper line in the diagram represents graphically what we can afford to pay for ties of different life to show the same merit as a tie costing $1 in the track and lasting 9 years. For example, suppose we have a chestnut tie lasting 9 years in the track and costing $0.655, to find what we can afford to pay for a tie which lasts 12 years. From the curve we find that the cost of a tie with life of 12 years is $1.262, multiply this by the cost of the tie of 9 years' life, $0.655, and we have $0.827, or the price we can pay for a tie with life of 12 years to show the same merit as the chestnut tie.

TABLE I.—COMPARATIVE VALUES OF TIES OF DIFFERENT MATERIALS.

Material.	Treatment.	Average life, years.	Cost in track.	Capitalization.	Annual cost.	Equivalent cost.	Order of merit.
White oak	None	9.0	$0.680	$2.286	$0.091	$0.680	25
Other oaks	None	6.0	0.625	2.981	0.119	0.479	30
Other oaks	Zinc chloride	11.0	0.730	2.083	0.083	0.801	23
Other oaks	Creosote	15.0	0.827	1.860	0.074	1.017	15
Other oaks	None	6.0	0.615	2.933	0.117	0.479	29
Pine	Creosote	15.0	0.750	1.687	0.067	1.017	3
Pine	Zinc Chloride	8.0	0.710	2.636	0.106	0.616	28
Pine	None	10.0	0.540	1.664	0.066	0.742	2
Cypress	Creosote	17.5	0.950	1.952	0.078	1.112	19
Cypress	Rueping	15.0	0.810	1.822	0.073	1.017	6
Cypress	None	9.0	0.655	2.202	0.088	0.680	24
Chestnut	None	5.0	0.550	3.089	0.124	0.407	31
Gum	Rueping	15.0	0.810	1.822	0.073	1.017	7
Gum	Creosote	17.5	0.835	1.757	0.070	1.112	4
Gum	Rueping	15.0	0.810	1.822	0.073	1.017	8
Hemlock	Creosote	17.5	0.950	1.952	0.078	1.112	20
Hemlock	None	12.0	0.700	1.863	0.075	0.858	16
Locust	Rueping	17.0	0.860	1.767	0.071	1.112	5
Locust	Creosote	20.0	1.000	1.840	0.074	1.243	14
Locust	Rueping	15.0	0.810	1.822	0.073	1.017	9
Hickory	Creosote	17.5	0.950	1.952	0.078	1.112	22
Hickory	None	4.0	0.550	3.787	0.151	0.330	32
Beech	Rueping	15.0	0.840	1.889	0.076	1.017	18
Beech	Creosote	17.5	0.950	1.952	0.078	1.112	21
Beech	Rueping	15.0	0.810	1.822	0.073	1.017	10
Tamarack	None	4.0	0.550	3.787	0.151	0.330	33
Maple	Rueping	15.0	0.810	1.822	0.073	1.017	11
Maple	None	4.0	0.550	3.787	0.151	0.330	34
Birch	Rueping	15.0	0.810	1.822	0.073	1.017	12
Birch	None	20.0	0.600	1.104	0.044	1.243	1
Catalpa	None	10.0	0.850	2.620	0.105	0.742	27
Redwood	None	15.0	0.810	1.822	0.073	1.017	13
Elm	Rueping	7.0	0.620	2.582	0.104	0.549	26
Fir	None	15.0	0.830	1.867	0.075	1.017	17
Fir	Zinc chloride						

TABLE II.—COMPARATIVE VALUE OF DIFFERENT TIES, USING TIE-PLATES.

Material.	Treatment.	Average life, years.	Cost in track, including two tie plates.	Capitalization.	Annual cost.	Equivalent cost.	Order of merit.
White oak	None	9.0	$0.680*	$2.286	$0.091	$0.680	7
Other oaks	None	6.0	0.625*	2.981	0.119	0.479	26
Other oaks	Zinc chloride	11.0	1.010	2.598	0.104	0.801	25
Other oaks	Creosote	15.0	1.107	2.375	0.095	1.017	18
Pine	None	6.0	0.895	3.448	0.138	0.479	31
Pine	Zinc Chloride	8.0	0.990	3.151	0.126	0.616	30
Pine	Creosote	15.0	1.030	2.202	0.088	1.017	4
Cypress	None	10.0	0.820	2.179	0.087	0.742	2
Cypress	Creosote	17.5	1.230	2.467	0.099	1.112	21
Cypress	Rueping	15.0	1.090	2.337	0.093	1.017	8
Chestnut	None	9.0	0.655*	2.202	0.088	0.680	3
Gum	None	5.0	0.550*	3.089	0.124	0.407	27
Gum	Rueping	15.0	1.090	2.337	0.093	1.017	9
Gum	Creosote	17.5	1.135	2.272	0.091	1.112	5
Gum	Rueping	15.0	1.090	2.337	0.093	1.017	10
Hemlock	Creosote	17.5	1.230	2.467	0.099	1.112	22
Hemlock	None	12.0	0.960	2.370	0.095	0.858	17
Locust	Rueping	17.0	1.040	2.282	0.091	1.112	6
Locust	Creosote	20.0	1.280	2.355	0.094	1.243	16
Locust	Rueping	15.0	1.090	2.337	0.093	1.017	12
Tamarack	None	4.0	0.550*	3.787	0.151	0.330	32
Beech	Rueping	15.0	1.120	2.404	0.096	1.017	20
Beech	Creosote	17.5	1.230	2.467	0.099	1.112	23
Beech	Rueping	15.0	1.090	2.337	0.093	1.017	11
Hickory	Creosote	17.5	1.230	2.467	0.099	1.112	24
Hickory	None	4.0	0.550*	3.787	0.151	0.330	33
Maple	Rueping	15.0	1.090	2.337	0.093	1.017	13
Maple	None	4.0	0.550*	3.787	0.151	0.330	34
Birch	Rueping	15.0	1.090	2.337	0.093	1.017	14
Birch	None	20.0	0.880	1.619	0.065	1.243	1
Catalpa	None	10.0	1.130	3.135	0.125	0.742	29
Redwood	None	15.0	1.090	2.337	0.093	1.017	15
Elm	Rueping	7.0	0.900	3.097	0.124	0.549	28
Fir	None	15.0	1.110	2.382	0.095	1.017	19
Fir	Zinc chloride						

*Tie-plates not used on these ties.—Note: Tie-plates assumed to cost 14 cts. each.

Cyanidation of Concentrate.*

By F. C. BROWN,† M. Am. Inst. M. E.

Probably most ores will come under the class of ores containing gold and silver finely disseminated through the various mineral constituents, as there are but few cases where all the valuable metal is in the form of free gold and silver, or where the gold and silver is in such forms as to be easily dissolved by cyanide solution. The ores and cases to which I especially wish to direct attention are those where the metals, other than gold and silver, if recovered in the form of concentrate, are not of sufficient value to cover shipping and treatment rates on the concentrate. In these cases; and there are no doubt many of them, it is advisable, if possible, to treat the concentrate at the mine for the recovery of the gold and silver, and allow the lead, zinc, copper, and other metals, to go into the tailing.

For the last three years I have been at a mine in New Zealand where just such conditions were present. The ore consists of a gangue of quartz and calcite containing the following minerals finely disseminated through it: iron pyrites, zincblende (chiefly the black variety), galena, some copper pyrites, and traces of arsenic, antimony, and selenium. By analysis it was estimated that 8 to 10% of the total weight of the ore consisted of these minerals. The gold and silver value of the ore was about $9 per ton (of 2,000 lbs.), about $1.50 of this being silver. There are no smelting concerns in New Zealand. Any concentrate produced has to be sent at heavy expense to Australia, and it was found that although 40% of the total value of the gold and silver content of the ore could be recovered in the form of concentrate there was little profit from the sale of the concentrate after paying bagging, carting, shipping and treatment charges.

Upon taking over the management of the mine I at once made arrangements for treating the concentrate at the mine, and a special cyanide plant was erected for this purpose. The results were highly satisfactory as it was found that a 90% recovery was effected at a fairly reasonable cost.

The concentrate treatment consisted of the following steps: (1) regrinding in tube-mill; (2) agitation by compressed air in Brown (Pachuca) tanks with fairly dilute cyanide solution; (3) vacuum filtration. Great difficulty was experienced in grinding the concentrate sufficiently fine. Some idea of the fineness necessary may be obtained from the fact that, before regrinding, all the concentrate would pass a 200-mesh sieve and it was estimated by time settlement-tests made in water, that the reground material would all pass 400-mesh if such a sieve were obtainable.

A fairly large tube-mill was required for about 10 tons of concentrate per day (24 hours), so it can readily be seen that the power consumption per ton was high, as was also the wear of pebbles and liners. After running the plant some months I came to the conclusion that such fine material by itself is too fine for economical grinding in tube-mills, and this opinion was strengthened by the fact that later, although very much finer grinding of the ore was tried and consequently finer concentrate produced, the percentage of extraction after regrinding was lower than when the ore was being crushed

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coarser. From this I inferred that the concentrate was not being reground as fine as before.

In order to overcome this difficulty it was decided to try adding coarse sand to the concentrate as it entered the tube-mill, the idea being that this gritty material would help the grinding, in the same manner that the barn-yard fowl picks up grit to grind its food. The result of this experiment was even beyond our anticipations, as it was found that the extraction was increased some 3 or 4% and the wear on liners and pebbles was materially reduced. It next occurred to me that the concentrate might advantageously be reground in the tube-mills used for grinding the ore, provided some simple method could be devised for continuously feeding it to these mills, there being always a good supply of coarse, gritty material in these mills to assist the grinding.

After numerous experiments such a method was devised and the success of the scheme was all that could be desired. This meant the abandonment of the special concentrate-treatment plant. The total extraction on the ore was higher than when the concentrate was treated separately. It is now about 90%, and the costs for labor and chemicals are considerably lower. This method of treating the ore and concentrate together has already been briefly described (the result of a communication from me), in an article by A. Grothe, president of the Mexican Institute of Mining and Metallurgy, which was published in the "Proceedings" of the Institute for August, 1909, "Cianuración de Concentrados," but this further reference to the method will be of interest to some.

I have come to the conclusion, since arriving in this country, that there are many mines in the Rocky Mountain regions situated away from the railroads, which, if they had a plant at the mine that would give a high extraction of the gold and silver content of the ore in the portable form of bullion bars, would give the owners materially increased profits compared with the present system of shipping the concentrate. This method of treatment might also bring about the resumption of work on some mines and the opening up of others.

Precautions for Maximum Safety and Effectiveness In Blasting.*

Electric Firing System.

Discharge of explosives by electricity is conceded to be the most effective system for blasting. It is often advantageous to set off more than one charge at a time, so that each helps the other in throwing down and breaking up the material to be moved, with the result that a greater amount of work is done by a given amount of explosive than if several charges were fired successively. This is successful only with electric firing. It is also possible to better protect against water with this system. Delayed explosions and misfires can be almost eliminated and the blaster can always be at a comfortable distance so that liability of accident is reduced to a minimum. The electric firing system is particularly preferable for gaseous or dusty coal mines on account of the elimination of open combustion for lighting fuses and through the elimination of delayed shots. In all underground work, burning squibs or safety fuse increase the smoke and fumes materially, and it is common for the burning fuse to flash through the tape and ignite the charge before detonating the blasting caps, with resultant poor execution and still more increase in fumes.

For electric blasting, four things are essential: (1) a hand generator (or a battery), (2) leading wire, (3) connecting wire and (4) electric fuses or squibs. Four more things are desirable for safety and economy: (1) insulating tape, (2) testing galvanometer, (3) testing rheostat, (4) leading-wire reel.

BLASTING MACHINE.—The "blasting machine," as the hand generator is called, is a small low-voltage series-wound affair, most commonly operated by pushing down the handle of a rack which works in and out of the case housing the dynamo. The rack rotates the armature through a gear train. The machine is short circuited on itself most of the time so that until the stroke is nearly completed the armature voltage is constantly building up. Near the end of the stroke this circuit is quickly opened to include the blasting circuit, and maximum armature voltage is impressed on the line causing sufficient current to flow to do the firing. Some of these machines are built to work on the upstroke of the rack and a few others of small size have the armature rotated by a strong spring which is released by a push button. Machines may be had to fire from 5 to 100 electric fuses.

The pocket battery is used for very small blasting operations and with it up to five charges

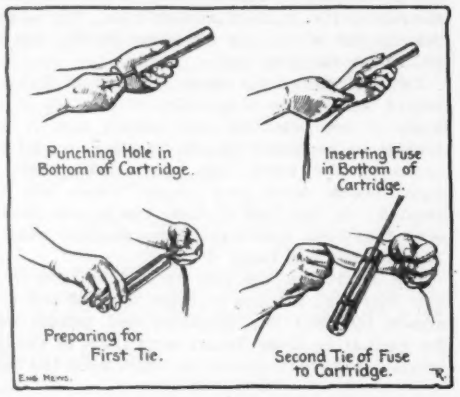
Punching Hole in Bottom of Cartridge.
Inserting Fuse in Bottom of Cartridge.
Preparing for First Tie.
Second Tie of Fuse to Cartridge.
Eng. News.

Fig. 1. Making Up a Primer For Electric Firing of High Explosive.

may be fired simultaneously. A half dozen dry cells are enclosed by a substantial wood case of such a size as to slip into a coat or blouse pocket. Such a battery weighs about 2½ lbs., as compared with 25 to 65 lbs. for blasting machines. Storage batteries are also used in a few cases for furnishing greater power than the dry cells can deliver without being cumbersome.

LEADING WIRE.—The wire used to traverse the distance from the blasting machine up to the vicinity of the charges is usually No. 14 B. & S. gage heavily insulated copper weighing about 2 lbs. per 100 ft. For convenience the two wires are often bound together with a braided coat, giving the appearance of a single cable.

CONNECTING WIRE.—For connecting the various electric fuses together and to the leading

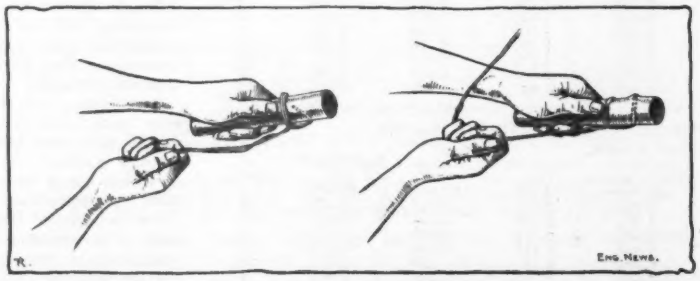

FIG. 2. HOW NOT TO MAKE UP A PRIMER FOR ELECTRIC FIRING.

wire it is not necessary to use as expensive conductor as is advisable for the latter. No. 20 B. & S. gage copper is large enough; No. 21 is sometimes used, but it is not recommended. The insulation may be just good enough for use once, for such wire will receive the full external shock of the blast and usually will be too greatly damaged for further service. Attempts to use old and damaged wires are often the cause of misfires. The wire may be broken inside the insulation and yet the ends may remain in contact until after testing.

ELECTRIC FUSES.—The detonator for high explosives is a copper shell containing the explosive charge, a mixture of mercury fulminate and potassium chlorate. Two cotton-covered, tinned copper wires enter the shell through a sulphur cement plug and the ends proje into the charge. A small platinum wire is s lered across the end of these wires; by the hea g of this bridge the charge is exploded. ctric fuses are commonly made in four sizes: ngle strength ("No. 4"), double strength ("N 6"), and the so-called "Nos. 7 and 8." The ngle strength may be used to explode straigh itro-glycerine dynamite but surer results are o ined with the double-strength detonator even h . No fuse smaller than the double-strength sh l be used with the so-called "ammonia dyn lite," "semi-gelatin," "blasting gelatin," etc., the "permissible explosives" of the U. S. Ge gical Survey. The Nos. 6, 7 and 8 are furnishe with a gutta percha covering for submarine ork. All fuses are made up with wires from 4 o 30 ft. long; a fairly long terminal wire mak con-necting wires between holes unnecessary.

To reduce the cost of electric firing, the ingle and double strengths are made with iron wires up to 8 ft. long. These, while cheaper, a not satisfactory under all conditions of blastin the iron wire is inferior mechanically and electrically.

What is known as "delayed action" fuses are made to detonate only after a certain interval of time from the passage of the flashing current. These are regularly made, in the "double strength" (No. 6) size, with either copper or iron wires and are of two kinds. One is known as "first-period" and the other "second-period," referring to the length of time interval. The delayed action is given by placing a short powder train between the platinum bridge and the detonating charge of the cap.

ELECTRIC SQUIBS.—Electric firing of charges of ordinary blasting powder is as desirable as with higher explosives. It is only necessary to use an electric squib instead of an electric fuse. These squibs are similar to the electric fuses, except that they have a paper cap in place of the copper one and the charge in the cap does not detonate but spits out a small flame against the powder.

The common miner's squibs are uncertain in rate of burning and in interval between shots. When many charges have to be set off, the blaster has to return to the working face several times, causing a loss of time and incurring some added risk. Any number of shots may be set off at once with electric squibs provided there is a blasting machine of sufficient capacity. These squibs are commonly made in a single size with copper or iron wires from 4 to 12 ft. long.

The advantage of igniting a charge of blasting powder at the center has always been evident and attempts have been made to do so with ordinary safety fuse. This, however, is seldom successful because most fuse, even the best gutta-percha covered, will spit fire through the sides. Center firing is perfectly feasible with electric squibs and, moreover, the bore hole has no vent left by burned fuse.

BLASTING CIRCUITS.—When the source of current is a blasting machine or battery, of the usual type, the bore holes should be connected together as a series circuit; one wire of the electric fuse or squib in the first bore hole is connected to one from the second hole, while the other wire from the second is connected to one from the third and so on. This leaves a free fuse wire in the first and last bore holes; these are to be connected to the leading wires from the blasting machine or battery. The common blasting machines and batteries will not satisfactorily set off detonators connected in parallel. Electric fuses and squibs are connected in parallel sometimes for firing from lighting circuits, but this practice is not standardized and is not generally recommended on account of increased danger from short circuits and grounds.

In making connections, all the metal parts intended to be in contact should be scraped clean and bright before joining. On the other hand, all parts not intended to be in direct contact should be thoroughly insulated from each other and from water or damp ground. All bare joints should be covered with insulating tape. The wires in being connected should be tightly

*Arranged in part from information to be embodied in a pamphlet "Blasting Supplies" (copyright 1910) to be published by The E. I. Dupont de Nemours Powder Co., Wilmington, Del.

twisted together so as to eliminate chances of loose or high-resistance contact.

Old and damaged connecting wire is often the cause of failures. The wire may be broken while the insulation may be intact and hide the fault. The ends of the broken wire may be in contact then, at the time of testing, but may be separated before the time for blasting. Similar trouble may occur with the heavier leading wire but as its far end only is close to the blast this part alone is subjected to the shocks of blasting and the greater length may be used until it becomes apparently old. It should frequently be carefully examined and tested, however.

ACCESSORIES.—The leading-wire reel is useful and will pay for its cost in reducing the time of running out the leads and in keeping the wire

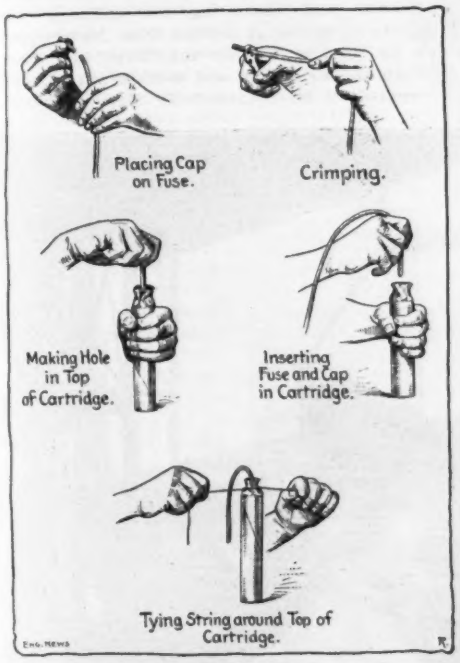
Placing Cap on Fuse.
Crimping.
Making Hole in Top of Cartridge.
Inserting Fuse and Cap in Cartridge.
Tying String around Top of Cartridge.

Fig. 3. Making Up a High-Explosive Primer With Blasting Fuse.

in good condition, prolonging its life. Such a reel weighs, empty, some 16 lbs., and will carry up to 400 ft. of double No. 14 cable.

The tape used in insulating bare spots and joints in the wires of the blasting circuit is about ¾-in. wide and usually comes in half-pound rolls of about 75 ft. The fabric is impregnated with a sticky insulating compound which holds it in place as applied. This tape dries out on exposure to the air, collects dirt and old pieces should not be used over again.

The testing galvanometer is a little instrument for learning before blasting if the circuit is in proper condition for setting off the charges. As ordinarily seen there is a vertical magnetic needle moving in the center of a coil of fine wire. Only a slight current is needed to move the needle and this current is furnished by a small dry cell permanently connected to the galvanometer circuit and carried in the case as a part of the testing outfit. When the galvanometer is connected to the blasting circuit, in place of the hand generator or battery, a slight current flows through the wires and through the fuses or squibs. This current is not large enough to heat the platinum bridges, but it gives an indication of whether there are troubles in the wiring and fuses or not.

The scale of the galvanometer, across which the needle pointer moves, is calibrated to show the electrical resistance of the circuit. The tester, knowing approximately the length of wire in his circuit and the number of bore holes, can ascertain from tables accompanying the instrument what the resistance of his blasting circuit should be. If his galvanometer does not reasonably well agree he must look for the troubles. If the galvanometer needle does not move at all, the supposition is that there is a break in the wires somewhere. If the galvanometer needle moves slightly, but shows too high apparent resistance, a poor contact somewhere may be sought, while if the needle jumps clear across the scale to zero or to some very low resistance figure a short circuit is indicated.

The galvanometer can be slung over the shoulder, by a strap attached to the carrying case, for convenience in work about the mine or quarry. No great precautions are needed and the instrument indicates properly if held as close to level as the operator can judge.

To know whether the galvanometer itself is in good condition, it can be tested with the rheostat mentioned before as a desirable accessory. Such a rheostat consists of a small wood case, usually, with a hard rubber cover carrying five binding posts, between which are connected various known lengths of resistance wire. The makers mark the resistance between binding posts, in equivalent number of fuses, so that by connecting the galvanometer to different posts the scale can be roughly checked.

In case the completed blasting circuit shows trouble, this can be located by going to the face of the work and testing different parts of the circuit.

The question is often asked, whether or not it is absolutely safe to pass the slight current from the testing set through the fuses or through a single fuse. The only answer is that there is nothing entirely safe in handling explosives. The greatest danger, of course, arises in locating breaks in a circuit with the fuses already in the loaded bore holes. If the tester is unwilling to take the slight risk, he may make his various readings at a safe distance by using a pair of leads which he knows are in good condition. This caution, of course, delays the localization of trouble. For testing fuses alone, the fuses may be placed in a pipe or other available receptacle.

PRIMERS.—The misfires with electric firing are probably nearly all due to carelessness in priming or loading and tamping the bore hole. The primer should be made up so as to preserve the continuity of the electrical circuit and the insulation of the fuse wires and so as to prevent pulling the fuse cap out of its best position in the priming charge.

The storage of the fuses and squibs should be given careful attention, for if they are kept in a very warm place the waterproofing material in the insulation of the wires will dry out so that the insulation may crack on being bent. Then a misfire results on wet work due to a shunting of part of the flashing current through

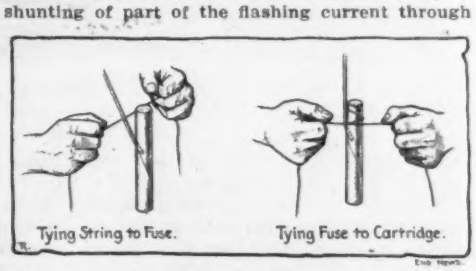

Fig. 4. An Alternative Primer With Blasting Fuse.

the water in contact with the wires. The explosive charge in the fuse is easily affected by moisture and if they are stored in a damp place they may deteriorate. Careful handling is also necessary to preserve the platinum bridge. The wires are not to be bent sharply or separated where they enter the cement plug.

The correct way of making up the primers for detonating a high explosive may be gathered from Figs. 1 and 2. The electric fuse should be inserted in a little hole in one end of the cartridge, pointing the cap directly toward the other end. The two wires should be brought together up one side of the cartridge, tying them with string an inch or two from each end of the cartridge.

The common practice of inserting the cap in a hole made diagonally in the side of the cartridge and of taking a half hitch about the cartridge is to be condemned. In the first place the sharp looping of the wires may break the insulation or even the wires. The cap in its diagonal hole commonly points toward the half hitch and pulling the wires taut tends to pull the cap to a position at right angles with the axis of the cartridge, often reducing the effect of the cap. These points are illustrated by Figs. 5 and 6.

Blasting Cap and Fuse Firing.

When it is not necessary to fire a high explosive in more than a single blast hole at one time, the old familiar blasting cap and fuse may be used. The cap is a copper shell like that of the electric fuse described and containing the same sort of a detonating charge. There are no wires entering the cap and there is no cement plug sealing in the charge. The shell is not filled with the charge, but considerable space is left so that the fuse may be pushed in and into contact with the charge. This fuse is a small rope of hemp or cotton yarn or tape with a core of fine grains of black powder and with the outside generally coated with a waterproofing mixture.

For this kind of firing with black powder the common miner's squib may be used in a needle hole or a length of fuse may serve to ignite the charge.

Fuse is made of four general kinds: (1) for dry work, (2) for damp places, (3) for wet work, (4) for use under water. The proper fuse will burn under water if immersed for only a short time and subjected to no appreciable pressure. Good results will be obtained with fuse adapted to the circumstances only when care is taken not to injure the fuse, when the joint between fuse and copper cap is made watertight with soap or tallow (if it is on wet or damp work) and when the charge is fired promptly. Oils or thin grease should not be used for making cap joints waterproof, as the oil or grease may soak into the fuse and affect the powder.

Common brands of fuse are generally known as "twenty-minute fuse." That means, if used in open air, the time required to carry through 50 ft., or an average of 24 seconds per foot. Some special brands are 20 to 50% slower.

Safety fuse should be stored in a cool dry place. Heat is apt to melt the varnish or to dry the fuse so that it breaks when unrolled. Moisture is absorbed by the powder core which then burns imperfectly. Before slipping a blasting cap onto fuse, a small piece should be cut off the end to remove damp powder or wrapping from which the powder core may have spilled out. The end of fuse should always be cut squarely across and never diagonally; the edge made by the diagonal cut may bend over, as the cap is slipped on, enough to prevent the flash from flying into the detonating charge. Safety fuse is made to fit the shell snugly and sometimes it may be a trifle too large. It should be reduced by squeezing and gentle working and not by removing any yarn or tape.

Most blasters still crimp the copper cap onto the fuse with their teeth or a knife. Besides being dangerous, these methods are apt to be ineffective. The cap should be very firmly fastened to the fuse to keep the detonating charge dry and to prevent pulling the fuse core out of contact with the charge in making up the priming cartridge and in tamping the bore hole. This can best be done with a little tool (called a "crimper" and looking like a pair of pliers) furnished by makers of blasting supplies. This tool also serves as a fuse cutter and it has a straight handle for making a hole for the cap in the end of the priming cartridge. The crimper may be hitched to the blaster's belt with a string or chain for convenience.

In making up the high-explosive primer, the paper end of a cartridge should be unfolded and a hole punched in the explosive with a pointed stick about the size of a lead pencil or with the smooth crimper handle. The cap should not be buried so deep that "side spitting" of the fuse will ignite the charge appreciably before detonation. The paper should be folded carefully up around the fuse and securely tied, as shown in Fig. 3. The cap may be placed diagonally in the side of the cartridge and in that case the fuse

should be tied securely to the cartridge, as shown in Fig. 4.

Primers should not be made up or stored in a magazine with other explosives. It is well to provide a special place where a sufficient quantity for immediate use can be made and stored. In some cases this will mean the erection of a separate small shack.

General Precautions for Safe and Effective Work.

THAWING.—A great many of the accidents in using high explosives are due to frozen nitroglycerin. Dynamite when frozen may fail to explode, either remaining intact or burning. Burning dynamite gives off poisonous fumes which are always harmful and sometimes deadly. Therefore, when dynamite is to be used at low temperatures, some provision must be made for thawing it and for keeping it thawed until it is loaded into the bore hole. While no methods are generally employed for heating the bore holes previous to loading, some such provisions are desirable if there is to be more than a few minutes' interval before shooting. The prevalence of accidents due to picking into unexploded parts of a charge (such as noted in Eng. News, March 12, 1908, p. 285) brings the advisability of this to mind frequently.

As common dynamite freezes at from 45° to 50° F., the thawing problem is troublesome. Where large quantities of high explosives are used, thawing houses are necessary and even then thawing kettles should be used to carry the explosives to the work and for storing it there until use. Accidents due to thawing have usually been due to improper methods rather than to inherent dangers of the process. It is common for contractors to put up a rough frame shack, cover it with paper and run in a steam coil in the bottom for heating. Here are opportunities for fire outside and inside, for overheating the explosive so that it may be absorbed by material in contact with which it may lie. There is a defective circulation of air and some of the explosive is not soon thawed. A model thawing house and magazine was described in Engineering News, June 25, 1908. A few essential features of all such houses may well be reviewed here. First they should be built so that a person cannot enter, thus removing the danger of overturning a lamp inside. There should be separate compartments for heating the air and for storing the explosive. A path should be provided for the circulation of hot air about the trays, and in some cases a small stack may be added to the house to increase the circulation. Where steam is not available for heating, a small water heater can easily be installed in a shed, which should be at least 10 ft. from the thawing house.

The thawing kettles are merely double closed-compartment pails, intended for hot water in the outer part. The dynamite compartment should be watertight, for the explosive under no condition should come in contact with hot water. These kettles come in many sizes, holding from 6 to 60 lbs of explosive. Some of the kettles are jacketed and will keep the dynamite thawed for six or eight hours. The larger ones hold their heat for five or six hours if kept in a barrel of hay. The barrel can then be mounted on a pair of wheels so that it can be drawn about the work from place to place as needed. Water for these kettles must be heated in a separate vessel, unless the inner part slips out, even though there is no explosive in the inner compartment. Nitroglycerin readily exudes from dynamite and enough is liable to be found in the inner compartment to cause an accident. The hot water should be tested before putting in the explosive; if it is too hot for the hand to bear, the explosive should not be put in.

TAMPING BAGS.—For damp work where high explosives are unsuitable, the black powder may be made up into cartridges with heavy paper. For this purpose, "tamping bags" of heavy paper may be purchased, as more convenient and safer than the hand-rolled cartridges. These bags come in several sizes, for cartridges of 1 to 1⅛ ins. in diameter, and from 8 to 16 ins. long. Such bags are of particular use in loading upward-pitching bore holes where loose tamping is very difficult.

BLASTING MATS.—The most effective way of preventing rock from being thrown into the air is by putting down mats woven from heavy hemp rope. If the charges of explosive are light, they may be spread loosely on the rock over the bore holes. For heavy blasting, large ties or logs should be used to weigh down the mats.

NECESSITY FOR STRONG DETONATORS.—In shooting with high explosives, the sharper and stronger the initial shock the more immediate and complete is the detonation of the whole charge. With the slower and less incomplete explosion, a greater charge is needed to do the work and a larger volume of poisonous gas is liberated. Where a minimum flame is required as in the presence of inflammable gas or dust, quick detonation must be secured.

Some electric fuses and blasting caps may be too weak to detonate a given charge of explosive but may generate heat enough to ignite it. Slightly stronger fuses or caps may only partially detonate a given charge and still stronger ones may cause a complete explosion but with insufficient rapidity to give satisfactory results. In purchasing blasting caps or electric fuses, it should be remembered that their charge is easily affected by moisture and a fair margin of safety should be allowed; blasting caps, being open at one end, are more quickly affected than the electric fuses. The cost of these detonators is very small in comparison with that of the charge of high explosive they are intended to set off, and a few cents' saving on a hundred detonators adds the risk of misfire, partial explosion and poor execution in the bore hole.

The effect of the detonator does not extend indefinitely along the bore hole. It is not only necessary to employ a heavy detonator with heavy charges but, in long bore holes, whether fired by electric fuse or by common blasting caps, it is well to place cartridges, each one containing a blasting cap, at intervals of 5 ft. With electric firing, it is also desirable to use two fuses in deep bore holes so that if one should happen to fail the other would give the initial detonation.

SELECTION OF EXPLOSIVE.—Speed in driving hard excavation, such as tunnel work, can be increased by a careful adaptation of explosives to the conditions met with from time to time. Some contractors find it advisable to try several kinds of explosive on a given rock which is encountered in quantity, care being taken to maintain constant conditions. If the character of the ground changes, then sometimes further tests are made to find the effect of quicker or slower explosives, heavier or lighter charges, etc.

High explosives for confined work, like tunnels, should be selected to give a minimum of objectionable gases—especially where ventilation is apt to be slow. For such work what are known as "blasting gelatin," "gelatin dynamite" and "ammonia dynamite" are available. The base of these compounds is formed by dissolving soluble nitrocellulose in nitroglycerin the product being a jelly. This is the quickest and strongest of all explosives and may be obtained in only one strength, the maximum. In many ways it becomes the ideal high explosive, but it is too powerful and shattering for ordinary work. Gelatin dynamite is derived from blasting gelatin by diluting it with the "dope" of common dynamite—wood pulp and sodium nitrate. Thus prepared, it is comparatively slow. It may be obtained in strengths varying from 35 to 80%—the ratings being intended to represent the same strength as the corresponding common dynamite. Tests by the U. S. Geological Survey, however, show small discrepancies. Ammonia dynamite is a little slower than the common dynamite, this characteristic decreasing with the strength. It comes in strengths rated at 25 to 75%. When the other compounds noted give too violent action, the ammonia dynamite may be used for its heaving effect. It contains nitroglycerin, ammonium nitrate and the diluting "dope," and is sold in several strengths rated like the gelatin dynamites.

The "ammonia" and "gelatin" dynamites are less readily set off than ordinary dynamites and require stronger detonators to insure quick and complete explosion. The "ammonia dynamites" take up water readily so that care has to be exercised in storage and loading. Water has little effect on the "gelatin dynamites," but they become less sensitive during long storage and are liable to decomposition by heat.

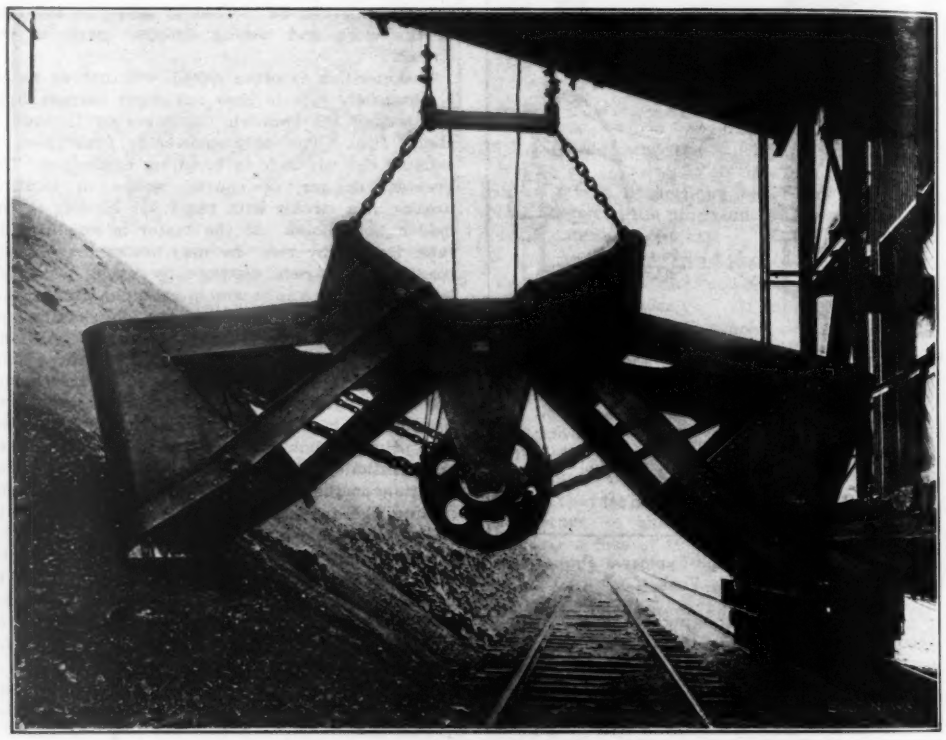

FIG. 1. A NEW TYPE OF GRAB BUCKET AT A COAL HANDLING PLANT (7½ CU. YDS. CAPACITY, 20 FT. SPREAD); OPEN POSITION.
(The Andresen-Evans Co., Chicago; Manufacturers.

HYDRAULIC FILL DAMS AND EMBANKMENTS are unknown in England, according to a statement by Mr. Martin Deacon, Assoc. M. Inst. C. E., of Westminster, England.

A New Grab Bucket for Ore and Coal-Handling Plants and Contractors' Use.

The development of ore and coal-handling machinery has been accompanied by the introduction of numerous styles of grab buckets, designed to have a greater capacity and greater facility of operation than buckets of the clam-shell type. These grab buckets are used also for handling other loose materials, such as sand, gravel, slag, cement, clinker, etc. They have been applied to a limited extent for excavation, and while their digging capacity is greater than clam-shell and orange-peel buckets, as a rule their weight is too great for handling by ordinary hoisting rigs. A new form of grab bucket weighing considerably less and having a greater digging power than the usual grab or orange-peel buckets has been introduced and placed in service, and this has among the special advantages claimed for it (1) powerful digging action, (2) light weight, and (3) simplicity of construction. The first two of these features especially are considered to make the bucket adaptable to general excavation and contracting work.

The bucket consists of two scoops, each forming the lower part of a braced frame; the back of each scoop is open, so that in closing there is no pressure tending to pack the contents of the bucket. It is built up of plates and structural shapes, and is well braced in all directions. The drum and other fittings are of cast steel, and the shafts are of steel in phosphor-bronze bearings. The shape of the bucket is such as to give a very wide spread when open (about 50% more than clam-shells), and one of the special features of the design is that each scoop is pivoted upon a separate hinge shaft, the width of spread of the open bucket being thereby increased by the distance between these shafts. This hinge arrangement gives also an efficient path of travel for the cutting edges. The hinge shafts and the differential drum for the closing mechanism are mounted in a central frame.

The open bucket is shallow, and therefore it can be operated readily under the deck of a ship; and when swung around at 90° in the hold its great spread enables it to readily take out material between the hatchways. Its width of spread is of advantage also in assuring a full load, whether taking material from a pile or cleaning up the hold or hopper. Further, in closing, the edges have no tendency to rise, thus cleaning up the material so that there is very little work for scrapers or hand shovelers in removing the last of the cargo. The drop of the scoop in opening is very small, so that the material may be deposited on the stock pile with a minimum fall; this permits of high stock piles and reduces breakage of friable material (such as coal) to a minimum. The wide base and low center of gravity of the bucket when open keep it from tilting when digging on the side of a stock pile.

FIG. 2. A 1½-YD. GRAB BUCKET IN USE FOR EXCAVATING ON CONTRACT WORK (1½ CU. YDS. CAPACITY, 12 FT. SPREAD).

In most other forms of grab buckets, compound lever arrangements are employed to give a digging action to the scoops in closing. In the new bucket this action is obtained by the simple rotary movements of the scoops around their separate pivots, thus simplifying the construction and permitting rigid bracing in all planes. It will be seen also that the cutting edges of the scoops descend through a considerable vertical depth in coming to the closed position, and have thus a positive digging action. In addition to this, the drum is placed low down (in relation to the pivots of the scoops) and the closing chains are attached to the back of each scoop, so as to give a downward pull with a large leverage throughout the stroke. This, combined with the efficient path for the cutting edge extended over the wide opening, gives the bucket its powerful digging action.

The bucket can be made light, as it is not dependent on its weight to dig, and therefore need not be dropped upon the pile in order to assure initial penetration, as is required with many buckets. Such dropping results in wear and tear of the bucket, and in handling coal it increases the percentage of breakage.

The bucket is operated by two lines (except on the large sizes; when it may be desirable to use more), and can be applied therefore to any of the double-drum hoisting plants commonly used by contractors and by many coal and ore handling plants. A single opening line is attached by a shackle to two chains leading to arms on the back of the bucket frames; or with a two-part opening line the hook of the hoisting block is attached to these chains. A single cable passing over the drum closes and hoists the grab.

For the 7½-yd. bucket on a coal-handling rig shown in Fig. 1, two opening lines are attached to a cross bar to which the bucket chains also are attached. Two closing lines are led to the differential operating drum, from which extend four two-part chains; there are two of the chains to each scoop, passing around sheaves on a shaft at the back of the scoop frame. The arrangement is such as to give a constant pull in a direction practically parallel with and opposed to the line of resistance met by the cutting edge, and the lever arm of this closing force is always comparatively great, giving a powerful digging action throughout the stroke. A somewhat different form of bucket and operating mechanism are used for three-line and four-line hoists.

The bucket is made in several sizes, with a capacity of 1 to 7½ cu. yds. This largest size has a reach of 20 ft. between cutting edges when open (Fig. 1). The 1½-yd. bucket (Fig. 2) is about 6 ft. deep when closed, and 4 ft. wide; its length over the scoops is 6 ft. 5 ins. when closed and 12 ft. when open. Its weight is about 3,600 lbs. if used for handling coal, or 4,500 lbs. for handling heavy material, such as iron ore.

The bucket is in use at four of the plants of the United States Steel Co., and at various coal handling plants. On a recent test in unloading a large lake steamer, this new grab bucket averaged 62% more coal per trip when taking out the coal directly under the hatch, and 71% more coal per trip when cleaning up, than a clam-shell bucket of the same rated capacity. It has also been used for unloading sand and gravel from barges (where a large saving was made in cleaning up due to its large opening), and in handling material for concrete mixing plants. It has been used for stripping work (digging hard clay, sand and gravel), and by contractors in excavating for dam foundations, sewer work, channels, etc. Fig. 3 shows the bucket in use for excavation (partly under water), and in this case it is handled by a derrick mounted on skids. It is stated that this bucket will dig equally well both under and above water, and in materials not satisfactorily handled by other types of buckets.

The grab bucket described above has been invented and patented by Mr. H. P. Andresen, and is being manufactured and sold by the Andresen-Evans Co., of Chicago, Ill.

Refuge Chambers in Coal Mines.*

By GEORGE S. RICE,† M. Am. Inst. M. E.

The recovery of 20 living men from an improvised refuge chamber in the Cherry mine, Illinois, one week after entombment, (Nov. 13, 1909), awakened general interest in the systematic establishment of equipped refuge chambers in coal mines. The employment of such chambers is by no means new. There have been a few well equipped refuge chambers established for years in certain mines abroad, and in at least one case in France they have been of value in saving life. The great number of mine disasters in this country, as well as the large percentage of such accidents to the number of men employed in the mines, makes the question of refuge chambers a most important one for us to consider.

In a majority of the mine disasters that have occurred in this country since 1907, there have been men in certain portions of the afflicted mine who have not been killed outright and who, in some instances, have lived for a considerable time, even hours after the explosion. This was notably the case in the recent Primero (Colo.) mine explosion. At this mine, a branch explosive wave entered the first working entry on the left for about 1,800 ft. and then died away. Fifteen miners in their working places beyond this limit of the explosion were not injured by violence or flame. One of them was ultimately rescued about 12 hours after the explosion. He stated they had wandered about for some hours trying to get out. In the last attempt they were overcome by the afterdamp and all but one died. It was evident that if they had remained in their working places all in this party would have escaped.

Had there been a refuge chamber in this vicinity with telephone connection to the outside, there is little doubt that these men could have gone there, and with good air and provisions, and encouragement by word from the outside, would have stayed in perfect safety.

*Abstract of a paper presented at a meeting of the West Virginia Coal Mining Institute, June 7, 1910.

†U. S. Geol. Surv., Pittsburg, Pa.

The rescue party would have had a definite place to work toward, and if necessary, could have employed oxygen helmets to reach the entombed men.

Windber, Johnstown, Wehrum and Herrin can be cited among recent explosions, in which some of the victims were lost by afterdamp.

Undoubtedly, prevention of disasters should receive the first consideration, but the facts are that disasters have occurred in well planned and in generally well administered mines, through some weak point undetected by the management, or through the failure of one man to understand or to do his duty.

LOCATION AND NUMBER.—The majority of mine disasters are due to explosions, and most of them in this country have their origin at the working faces. Usually the main explosive wave rushes along the haulage road that provides its fuel—coal dust—until it reaches the exits into the open air. There are frequently branch explosive waves that traverse some of the cross headings or entries. More particularly is this true when the rooms are connected through from heading to heading and provide an abundant supply of fresh, dry coal dust.

In exceptional cases, notably at Marianna, Pa., and recently at Mulga and Palos, Ala., the flame of the explosion penetrated throughout the mine. In these mines there was a small amount of methane given off in the working faces, which undoubtedly tended to widen the explosion in each case. In a typical coal-dust explosion, where there are some wet stretches of passageways wet from either natural or artificial causes, there are likely to be some roads and districts unpenetrated by flame. This suggests the value of a refuge chamber in each district and a complete separation of one district from another by continuous pillar, where the room-and-pillar system is used. The entrance and exit for haulage and ventilation of each district should be located at one point and the entrance and exits protected by special zones which are kept free from dust, or the dust thoroughly wetted or covered by rock dust.

Such information as we have at present leads to the belief that these zones can be made impenetrable to an external dust explosion when uncomplicated by the previous presence of methane in the air passing through the zones. The latter would be an exceptional condition. An explosion within a given district would probably traverse its respective protection zone and possibly reach the nearest exit to the open air, but the explosive wave should not enter the other districts if the inert zones are properly arranged and protected.

The maximum size of a district to be supplied by a refuge chamber depends somewhat on the geological and other physical conditions presented by the seam and the system of working same. It would seem desirable to have it bear some relation to the maximum number of men employed in a district ventilated by a separate split of air. We will assume that the maximum number of men is 100, a not uncommon maximum allowed for a single split of air. As there will be new districts or panels forming while others are being worked out, the average number of men we will figure at 50. A medium-sized mine has about 200 men employed on the day shift, and a large mine about 500. Accepting the average of 50 men in a district, there would be from four to ten live districts in a medium to large-sized mine, and the same number of refuge chambers under the system proposed.

Suppose, then, there be a refuge chamber in each isolated district, the miners acquainted as they should be with the location of the chamber, rush to it on hearing the explosion or being notified of it if in a distant district. In an inclosed district, the afterdamp would come in only slowly at the entrance until the explosion doors at the fan had been replaced, so that in most cases in a carefully planned district the men would have ample opportunity of reaching the refuge chamber before the blackdamp drifted or was blown in.

DRILL HOLES.—Such a chamber should be connected by a protected telephone line with the surface, preferably coming down a drill hole direct into the chamber. This drill hole could also be used for supplying fresh air under pressure. Under such circumstances, the imprisoned men, encouraged by communication with the outside and supplied with stored food and water, could live for weeks, if necessary.

To establish these refuge chambers may appear to be a serious task, but my idea is that if these chambers are planned in laying out the mine, the cost per ton would be insignificant. Nearly all modern coal developments, as a matter of good engineering, are, or should be preceded by thorough prospecting, both to know the continuity of the seams and to properly plan the mine. Furthermore, in gassy seams, according to Fred. Keighley, as reported in his paper delivered before the Mining Institute of Western Pennsylvania, 1899, drill holes are of great value in draining off the gas contained in the seam. If the prospect drill holes are cased and protected from injury at the surface, they will serve as the most valuable feature of a refuge chamber, providing means for communication to the outer world.

It is true that while such drill holes are preferably large, the ordinary prospect hole drilled by a core-drill which may be cased with 2-in. pipe will accomplish all that is strictly necessary, provided there is an air compressor available. By a recently developed system of boring holes, that of Brejoha's,* which has been employed abroad, the hole is coated with cement, thus dispensing with casing and giving a larger internal diameter. The telephone wires could pass down this same casing through which air is forced.

It is possible to obtain nearly the same results by carrying the pipe lines and telephone lines through the mine and omit the drill holes, but to render them secure against explosion or fire would require burying or recessing, so that the cost would probably be greater than the drill-hole arrangement, and the latter would certainly be much surer.

In rough figures, ten liters of free air per minute will be sufficient per man, or assuming a maximum of 100 men in the chamber, 1,000 liters of free air at atmospheric pressure per minute will be required. This is equivalent in round numbers to 350 cu. ft. at atmospheric pressure per minute. Compressing to six atmospheres, this would mean only 60 cu. ft. of air per minute compressed to 80 lbs. per sq. in.—which could easily be delivered through even a one-inch pipe to depths of over 1,000 ft. The exhaled and surplus air would be discharged into the mine.

If the drill hole be made large enough, it has been suggested that a hand-driven suction fan could be placed at the bottom of the hole in the chamber, so that the refugees would be independent of external machinery to get air. In putting in such a fan it would be advisable to offset same by a tee from the foot of the hole and insert valves so the hole can be used in other ways.

SIZE AND SHAPE OF CHAMBER.—Allowing room for each man to stretch out on the ground, say 12 sq. ft. each, it would require 1,200 sq. ft. of area in the chamber for the maximum number of 100 men. If the chamber is 18 ft. wide, the length needed would be 66 ft.—we will say 75 ft. in length—although there would be no objection to much greater length. The chamber may therefore be an ordinary working room and driven as such, though for sake of speed in preparation in each given district, it may be advisable to limit the length to 100 ft.

The two chief features to be observed are (1) to make the room, neck or necks, of great length; (2) to make the pillars on either side of good thickness, and make the crosscuts to adjoining rooms or entries in the process of driving the room as narrow as possible, so as to lessen the difficulty and expense of building tight masonry or concrete stoppings in same on completion of the chamber.

Where the State laws do not require crosscuts nearer than 80 to 100 ft., the refuge chamber could be driven up without crosscuts, using instead a line brattice to carry ventilation to the face.

ENTRANCES.—The entrance to the chamber, after the crosscuts have been securely and strongly sealed, should be at the heading or entry only. There should be two entrances at the heading where practicable. The reason for two is to provide for ventilation under ordinary conditions, and in case there should be a fall of roof on the entry, blocking one of them, the other entrance would be available.

The entrance used in driving the chamber would have to be wide enough to admit a mine car, though this width should subsequently be reduced by heavy masonry securely keyed into the ribs to keep down the width of the doors to about 30 ins. The other entrance could be driven narrow by pick. Normal ventilation would be established by placing a curtain across the entry or heading, and if necessary, carrying a line brattice up the room. Opposite one of these entrances there should be a crosscut, with doors, through the pillar to the parallel heading or entry to allow the men to enter from that side. The entrances into the chamber should each be guarded by at least three strongly built doors with frames recessed into the rib or masonry.

It does not seem essential that these be made of iron. It is rare that fires resulting from explosions are started in the interior of the mine, without immediate extinguishment by the afterdamp. When fires result from an explosion it is usually near the entrance, where the fresh air has come in before the coked dust has cooled off. There is no objection whatever to iron doors, but it is better to keep down the expense of installation and have frequent refuge chambers instead of one or two very expensive ones.

The doors should open inward to the chamber and normally be kept open by a button, though self-closing. This applies to district chambers in the interior of the mine and not to a special fireproofed chamber, such as has been proposed for instalment at an escape shaft, and in which it may be better to keep the doors closed.

The first men entering the district would shut the doors. The doors should be carefully hung and fit tight, but no extra or unusual tightness would be required if there was a cased drill hole from the surface, down which air could be forced under pressure. It may, in fact, be found necessary to provide a pipe recess along the rib behind the door casings with an automatic relief valve in same to prevent excessive air pressure on the men, should the doors seal very tightly.

EQUIPMENT.—The equipment of the district refuge chambers should be protected and should be relatively simple. The vital feature is the drill hole for ventilation and for carrying down telephone lines, and in case of prolonged entombment, for running down water or liquid food.

The telephone itself should be of the iron-inclosed type and would be useful in the regular administration of the mine. Its use in this way would tend to insure its being in order when needed. In a rib hole or one of the sealed crosscuts, there should be a privy provided with sand and disinfectants. The chamber should be whitewashed throughout and the floor kept sweet.

Drinking water should be kept in covered casks and renewed from time to time. Food in cans and tins should be stored in wall cases with glass fronts, the latter to be broken when necessary. A dozen or more dry-cell electric lights should be placed in the wall cases also two or three safety lamps with match relighters.

One oxygen resuscitation box with an extra oxygen cylinder would be most desirable. Two or more sets of oxygen rescue apparatus might also be of advantage for exploration toward the shafts or for fighting local fires. Light, portable self-rescue apparatus, like that designed by my colleague, Clarence Hall, might be of great service. Two or more portable chemical fire extinguishers would be excellent for regular protection of the district, rather than for the more remote contingency of fighting fires produced by an explosion. There should be a roll of canvas or brattice cloth for special emergencies. Disinfectants, simple medicines, and a box containing "first-aid" remedies and implements would manifestly be of advantage.

The list can be added to indefinitely, but the main thing is to have the apparatus and supplies kept in such a way and so maintained as to always be instantly available. In a well-administered mine this should not be difficult, and, if severe penalties are inflicted on those who take away or damage the equipment in ordinary times, the cost of maintenance should not be great.

Fireproof Refuge Chamber Near Shaft.

In shaft mines, one chamber near the escape shaft would be advisable. Such a chamber should be fireproofed and have iron doors. It would be of great value to men who might be able to reach the bottom after any explosion before the hoisting arrangements, if injured, had been repaired. It would also be of advantage as a hospital and as a base for rescue parties. The arrangements at the foot of shafts are so varied it is impossible to specify as to the size or shape. The general equipment would be the same as for the district chambers.

If a mine is equipped with refuge chambers, it is manifest that signs and directions should be placed along the headings leading to same. Each new employee should be taken to the several chambers and the equipment carefully explained to him in his own language. Nothing should be taken for granted.

Cost of an Average District Refuge Chamber.

In the following estimate, the room is not considered an added expense, except for the extra length of room neck. The cost of drilling the hole is considered part of the cost of prospecting; the cost of its casing alone for an assumed depth of 500 ft. is considered. The telephone is not regarded as an extra cost.

COST OF REFUGE CHAMBER.

500	ft. 2-in. common-pipe casing in place	$50
50	ft. of excess room neck yardage and special entrance	50
5	room crosscuts, say, 100 ft. of yardage	50
5	Masonry stoppings, at $10	50
6	Masonry door frames, at $5	30
6	Doors and frames, at $6	36
	Sanitary closet and fixtures	15
	Wall cases with glass fronts	20
	Casks, pails and miscellaneous fittings	10
	Food in tins and cans	25
6	Dry cell electric lights, at $5 each	30
2	Safety lamps, at $5	10
1	Oxygen resuscitating box, with two cylinders	45
	First aid box; medicines and disinfectants	25
	Miscellaneous	54
	Total	$500

The foregoing provides for a good equipment; other apparatus mentioned previously should be considered as part of the mine equipment.

If a mine had six such stations, the cost underground would be $3,000. On the surface the special equipment would vary widely with the physical conditions and regular equipment. If a mine used compressed air, the only additional cost for the stations would be the outside pipe lines. These pipe lines need not be large, as economy of operation would not enter into the calculations. It is probable that all such lines to drill holes of six refuge chambers could be supplied at from $1,500 to $2,000, under ordinary conditions.

When the mine has an electric plant, but not a compressor plant, the additional surface equipment would be the cost of the power lines to the various drill holes and the cost of the small motor-driven fans or com-

*"Colliery Guardian," Vol. XCVI., p. 502.

...sors. Each drill hole surface installment could probably be put in at a cost not exceeding $500.

When a mine had neither compressed-air nor electric plant, the cost of instalment would, of course, be much greater, as it would involve a small central plant. However, it may be pointed out that such a plant would be extremely useful, and no doubt pay for instalment in other ways.

Let us assume that the average total cost of installment of district refuge chambers figures as much as $10,000, or let us say 5% of the total cost of the mine investment. The possibility of saving a considerable number of lives, if disaster comes, makes it seem a good investment.

Sewage Disposal Under Difficulties at Leicester, England.

It is doubtful whether any city in the world gets rid of its sewage against such odds as does Leicester, England. Not only is the sewage pumped a long distance and to a high elevation, but in addition it is treated in sedimentation tanks, single contact beds, a humus settling chamber, again pumped, and then given a final purification on a large sewage farm This does not tell the whole story. The land composing the farm is of heavy clay so ill-suited to the reception of sewage that it is necessary to apply the sewage a second and in some cases a third time before a satisfactory effluent can be obtained. An interesting paper describing the Leicester sewage works was read before the Royal Sanitary Institute on April 22, 1910. The paper was by Mr. George Mawbey, M. Inst. C. E., Borough Engineer and Surveyor of Leicester, under whose direction the works, after their early inception and partial completion, were carried out.

For many years the sewage of Leicester was purified by broad irrigation alone. After a large increase in population through natural growth and annexation and a material increase in the strength of the sewage, the land became so much overburdened that measures for its relief were necessary. Experiments made under Mr. Mawbey's direction led to the conclusion that the system of preliminary treatment best suited to local conditions consisted of a period of sedimentation short enough to avoid septic action, followed by the passage of the tank effluent through single contact beds. The preliminary works as finally constructed also included a settling tank for the removal of humus from the contact bed effluent.

The population of Leicester is about 235,000. The total dry-weather flow of the sewage to the present treatment works is about 8,000,000 gals. (Imp.), or about 9,600,000 U. S. gals. per day, which is an average of about 42 U. S. gals. per capita. About one-fourth of the dry-weather flow is trade waste, chiefly from dyeing, wool scouring, fellmongers' and curriers' establishments. The crude sewage is slightly alkaline.

Nearly all the sewage is pumped to the sewage farm through two 33-in. cast-iron force mains about 1⅛ miles in length and with a total lift of 166 ft. The balance of the sewage, or some 600,000 U. S. gals. per day, dry-weather flow, is pumped through a 15-in. force main nearly two miles to a height of 180 ft. The main pumping station is capable of lifting a sufficient quantity of storm water to bring the daily total up to 24,000,000 U. S. gals. There is also excess capacity over the dry-weather flow at the smaller pumping station, so that both plants can deliver some 26,000,000 U. S. gals. to the purification works.

At the purification works the sewage is first received in seven sedimentation tanks, each 98½ ft. long with a total capacity of 1,800,000 gals. (Imp.), or 2,160,000 U. S. gals. The tank capacity is nearly equal to one-fourth the dry-weather flow. An equalizing tank for receiving part of the sewage which has passed through the settling tanks brings the total tank capacity up to a little over one-fourth the dry-weather flow. This relatively small tank capacity compared with British practice generally, was based on the results of Mr. Mawbey's experiments of 1898-9 when he

found that advanced septic action certainly retarded, rather than facilitated, the purification both in the beds and upon land, and that the best and most rapid results were obtained with a tank capacity of about one-sixth to one-quarter of the dry-weather flow.

PURIFICATION EFFECTED BY SEWAGE PURIFICATION WORKS OF LEICESTER, ENGLAND, APRIL 4-5, 1910.

(Parts per 100,000.)

	Crude sewage	Tank effluent	Bed effluents			Average of five land outfall effluents
			Slag	Slate	Granite	
Suspended matters	73.	19.5	7.5	7.	7.	.84
Matters in solution	112.	....	....	....	....	117.
Chlorine	11.4	10.4	10.	9.8	9.8	11.1
Free ammonia	4.0752	4.1869	2.0205	2.9313	2.9313	1.5202
Albuminoid ammonia	1.6028	.7188	.5683	.527	.5221	.2158
Oxygen absorbed at 80° F. in 4 hours	10.606	6.06	3.2	3.332	3.2	1.3975
Dissolved oxygen (volumes per 1000 volumes)	....	....	....	....	....	3.48
Nitrogen as nitrates	....	....	....	....	....	.38

The effluent from the settling tank passes to single contact bacteria beds (Fig. 1) having a total area of 12 acres. The underdrains of these beds consist of V-shaped earthenware tiles laid about 4½ ft. apart, and at an angle of 30° with the main drainage channel, which is formed in the concrete floor of the beds. The space between the tiles is filled with two courses of ordinary brick "honey-combed or checkered" like the brick sometimes placed in water-works filter

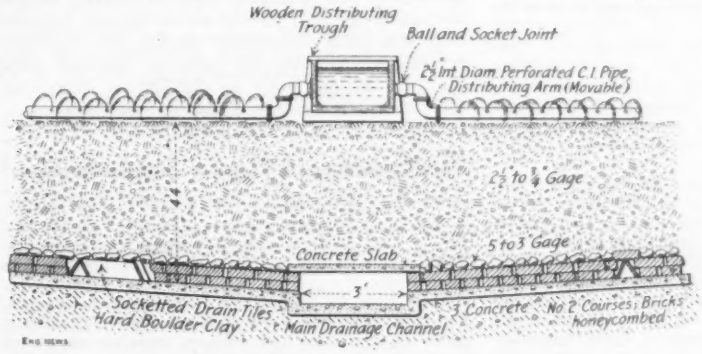

FIG. 1. SECTION THROUGH SINGLE CONTACT BED, SEWAGE WORKS OF LEICESTER, ENGLAND.

(Shows central trough and perforated movable arms for distributing sewage, material composing beds, and V-shaped underdrains.)

beds. The material composing the beds is of various sorts, including broken bricks, limestone, granite, slate, destructor clinker and furnace slag. Between the upper part of the drainage tiles this material is from 3 to 5 ins. in size, while the main part of the material is from ¾ to 2½ ins. in size.

The beds are filled to an average depth of 4½ ft., giving a water capacity of about 360,000 U. S. gals. It was found in the autumn of 1909 that the water capacity was equal to 40.62% of the gross capacity of the empty beds, which was a reduction of 9.3% from the original capacity. At the time the tests were made the beds had been filled from 647 to 1,427 times each during

Fig. 2. Method of Distributing Settling-Tank Sludge Over Arable Land at Sewage Farm of Leicester, England.

the two years in which they had been in operation.

On the average each bed is filled in about two hours, remains full about two hours and is emptied and rested for the same period, thus making a full cycle occupy eight hours. Each set of four beds has three fillings per 24 hours for one week, two and a half for a second week and only one filling per 24 hours the third week, and is then given a complete rest for the fourth week.

The sewage is distributed over the beds by the combination of wooden troughs and perforated movable cast-iron arms shown in Fig. 1. The movable arms are said to prevent clogging of the beds. The arms are moved to a new position about once a week, and their "perforations are kept clear by occasionally passing a wire brush up the tubes."

The effluent from the contact beds first passes by gravity to an underground channel with a capacity of 300,000 U. S. gals., which acts as a settling tank for such humus as comes from the beds. The sludge from this channel is drawn off twice a week to the sludge pumps, mentioned below.

The sludge from the settling tanks is removed about once in three weeks and amounts to about 15½ long tons per 1,000,000 Imp. gals. (or about 14¼ tons per 1,000,000 U. S. gals.). The average per cent. of moisture is 91.2. The three-week period of removal has been found to be the longest possible without the production of gases in the bottom of the settling tanks. Such gases "throw up large quantities of solids which flow off into the contact beds."

The sludge is forced by centrifugal pumps through 9-in. and 6-in. mains to different parts of the farm. Some of it is dried on specially prepared arable land (Fig. 2); some in lagoons, air-dried and finally removed either by neighboring farmers or for use on the sewage farm itself.

The contact bed effluent, after passing through the humus-settling tank already mentioned, is lifted by a centrifugal pump through two 40-in. cast-iron force mains into a high-level channel which commands the whole farm.

The Leicester sewage farm is so unique that we give Mr. Mawbey's description of it in full:

The area of the farm is 1,710 acres, of which 1,234 are available for sewage treatment, the remainder being used for feeding the cattle when it is convenient for them to graze on the irrigated land. Something like one thousand bullocks are annually fed upon this land, the Farms Committee supply the horses for most of the departments of the Corporation, and a large proportion of the provender is also supplied from the farm.

Of the sewaging area, about 230 acres are arable, about 274 acres rye grass, and about 730 acres old pasture.

The depth of the surface soil varies from about ½ to 1 ft., under which there is a depth of about 2½ to 3½ ft., of yellow clay, overlying hard boulder clay, averaging some 100 ft. thick, resting upon the Upper Keuper Marl.

In the first place the Corporation purchased only 100 acres of land, upon which the first detritus tanks were constructed, the remainder being held on long leases; but owing to the success of the undertaking, they have purchased a further 1,270 acres of the land, which is mostly used for irrigation.

The main carriers, etc., for this Beaumont Leys irrigation scheme, the Abbey pumping station and rising mains, as well as the main trunk sewers of the Borough of Leicester, were designed by my eminent predecessor, the late Mr. Joseph Gordon, M. Inst. C. E., and were mostly carried out by me. It is only fair to mention that this scheme for irrigation of clay land was by no means Mr. Gordon's favorite one, and he designed several other excellent schemes; but owing

to the insurmountable difficulty in obtaining the more suitable lands of sufficient area which he preferred in other localities, and as this land could easily be obtained, and had also the advantage of almost complete isolation from building areas, this scheme became practically inevitable.

The purification of the sewage on the clay land was a most difficult problem to solve. It was indispensable that the land should be underdrained, without which it would have been impossible to successfully work the arable portions in very wet seasons. On the other hand, with only about 1 ft. of top soil, it was certain that the sewage would reach the drains in a foul condition, and it was, therefore, not surprising that failure was predicted.

Along the bottom of each field is laid a main drain, and all the branch drains of this field, which are 3½ to 4 ft. deep, and vary from 24 to 66 ft. apart, are connected therewith. Taking advantage of the slope of the land, which has a considerable fall each way from the watershed, the main from each field is brought out as soon as possible on to the surface of the next lower field or area.

At the outfall of each drain, a small valve chamber with two outlets, is constructed by which the effluent reaching the drains from the land under sewage can be turned onto the surface of the lower lands over and over again for further treatment, or, when sufficiently purified, can be discharged direct into the effluent dikes close by.

The ordinary ditches by the hedge sides all over the farm were in the first place cleaned out and lowered to a depth of about 4½ ft., and made to answer for clean effluent water drains to carry off the purified sewage to the main water courses, in the same way as they had previously answered for the natural drainage of the land.

The surface effluent which does not reach the drains is prevented from flowing into the ditches by means of intercepting earth grips parallel with the ditches, so arranged that it can be distributed a second or third time over lower-lying fields for complete purification as may be required, and, when purified, turned into the nearest effluent dike. This system is, of course, the ordinary method which is practically always adopted for surface effluent in broad irrigation. It must, however, be pointed out that low-lying flat clay land could not be so treated, and, therefore, would not be suitable for sewage purification.

I cannot speak too highly of the great final purifying effect produced by the surface irrigation over the old pasture land. It is wonderful to see the immense improvement effected by the passage of the clarified sewage over the surface of one of these fields.

Another matter which deserves mention is that, when the land became overworked, and before the bacteria beds came into operation, both the arable and grass land rapidly became very heavily sludged up for a long distance from the point of application of the sewage. The effect of the bacterial clarification process has been that, with the exception of slight fouling for a very short distance from the upper feeding grips, the grass all over the farm is remarkably clean and almost entirely free from fouling.

The effluent from the Leicester side of the sewage farm flows back through an open dike, parallel with the rising mains, to the Abbey pumping station, where it is discharged into the river Soar.

The effluent from the Leicester Forest side is discharged through three outfalls into the Anstey brook, which, after flowing about 3½ miles, joins the river Soar about 4 miles below the Abbey pumping station. In summer, the volume of the brook scarcely exceeds the volume of the effluent discharged into it.

The volume of the flow of the river is often exceedingly low in times of drought; nevertheless, the river from Leicester for many miles down is stocked with fish, and is a popular resort for anglers. On the other hand, when I was appointed at Leicester, a little over twenty years ago, before the Beaumont Leys sewage farm was laid out, and when the sewage of Leicester was chemically treated at the old works, the river for miles down was black and putrid with sewage pollution.

Towards the end of his paper Mr. Mawbey gives the results of chemical analyses of the crude sewage and of the effluents from the various beds. The average composition of the crude sewage for ten years was as follows:

(Parts per 100,000)

Suspended matters	68.12
Matters in solution	112.6
Chlorine	12.74
Free ammonia	4.5128
Albuminoid ammonia	1.5609
Oxygen absorbed at 80° F. in 4 hours	12.5396

During the quarter preceding the reading of Mr. Mawbey's paper the combined effect of the sedimentation tanks and contact beds was to remove 92.25% of the suspended matters shown by the crude sewage and 75.13% of the oxygen absorbed at 80° F. in 4 hours; the corresponding removal for the final land effluents were 98.2 and 94.1%, the actual figures in this case being 1.22 parts per 100,000 of suspended matters and 0.74% of oxygen absorbed at 80° F. in 4 hours.

As a typical illustration of the results obtained by the various parts of the works and by the works as a whole Mr. Mawbey gives the analyses based on hourly samples taken on April 4 and 5, 1910 (see table herewith). The results shown are stated to be "by no means" of the best.

The samples of crude sewage were taken hourly. The tank effluent samples were taken half-hourly from 11.30 a. m. to 1.15 p. m. The bed effluent samples were also taken half-hourly, but from 3.15 to 4.50 p. m.

In commenting on the figures shown in the accompanying table Mr. Mawbey remarks that the average total purification effected for April 4-5 was 86.3% in albuminoid ammonia; 86.2% in oxygen absorbed at 80° F. in 4 hours; and 98.95% in suspended matters.

The total cost of the sewage purification works has been £425,287, or $2,066,895. Of this the land owned by the borough cost £187,000, or $908,820. The pumping stations, rising mains, sewage farm distribution works, tanks, bacteria beds and effluent pumping station cost £238,287, or $1,158,075. The 12 acres of bacteria beds cost £4,286 per acre, or $20,830, a little over half of which was for filling material alone.

Tar-Macadam: A Plea for Standardization.*

By J. WALKER SMITH, City Engineer of Edinburgh.

That it is becoming a generally-accepted opinion that tar in some form or other is destined to play an important part in the road construction of the future is undoubted.

Apart from its comparative dustlessness—the essential and most important characteristic in respect of which it holds an advantage over ordinary macadam—it is now practically reduced to an axiom that a tar-bound macadam road has enormous advantages over an ordinary macadam road in the following respects:

Economy of maintenance, through its ability to better withstand agents of road destruction, both tractive and climatic; economy of scavenging and watering; a flatter permissible camber; noiselessness and hygienic advantages.

Disadvantages have from time to time been raised, but of these there are apparently two only that have survived; extra cost and slipperyness.

Dealing firstly with the latter alleged disadvantage, it must be admitted that, compared with ordinary macadam roads upon the occasion of frost, there is a somewhat greater tendency to slipperyness for horses upon tar-bound roads; but for self-propelled vehicles there is practically no disadvantage in this respect under any conditions of weather, and the occasional slipperyness to horses is no greater than upon compressed or mastic asphalt, or similar smooth paving; and tar-macadam—in those circumstances where mud cannot be readily introduced from ordinary macadam surfaces—is infinitely less slippery for self-propelled vehicles in slightly wet weather on account of the absence of the film of greasy mud which frequently overlies macadam, wood-paved and other similar road surfaces.

Then, secondly, as to the question of additional cost; much will depend upon local circumstances governing the costs of ordinary macadam.

The differences in conditions affecting costs of ordinary macadam road construction are so wide in various parts of the country that it is not proposed here to discuss that aspect of the case, as it will be well known to each engineer or surveyor of his own district what the cost of ordinary macadam may be, and adapting certain facts and figures to conditions which obtain in his own district he will be able to estimate the cost of tar-macadam construction in order to obtain relative or comparative results.

There are many different methods of preparation and laying of tar-macadam. There are patent methods and proprietary articles that would come within the category of tar-macadam. No good purpose would here be served by discussing each, or indeed any, of these methods and articles, for it is presumed with some degree of confidence that the two systems of tar-macadam construction at present known which are destined to survive and play an important part in the future are pitch-macadam and tar-concrete or ordinary mixed tar-macadam.

Thus are excluded all patent and proprietary articles and methods which are considered unnecessary [illegible] indeed undesirable in the interests of national [illegible]roved road construction.

Limiting oneself to the consideration of th[illegible] two methods it would be well briefly to describe the[illegible]

Pitch-Macadam.

A layer of 2-in. dry, hard stone is evenly s[illegible]d on the foundation to a thickness of 3 ins. and rol[illegible] dry. This layer is then grouted with a mixture of h[illegible] pitch and sand, and again rolled in order to thorough[illegible] consolidate the mass and reduce the interstices. A [illegible]cond coat of stone, 1½-in. gage, to finish to the [illegible]uired thickness, is then evenly spread, preferably w[illegible] the bottom layer is still hot, rolled dry to an even [illegible]face, similarly grouted to the bottom coat, but with [illegible] admixture of a small amount of cement to the pi[illegible] and sand, and well rolled while hot, the surface [illegible]being blinded with dry chippings of the same stone [illegible] the macadam. This method would apply to a new ro[illegible], and would, with a top coat spread 3 ins. thick, lea[illegible] it 5 ins. thick consolidated.

In the case of a reconstruction of an existing macadam road the larger material is riddled out and used for the bottom coat, for which it is quite suitable. In any case, the use of first quality granite for the bottom coat is now abandoned, as a greatly inferior stone will do equally well, and the granite may be reserved for the surface; it may in places happen that good granite in first-quality stone is as cheap as any, in which case it will, of course, be used to the bottom as well as the top coat.

There are now in this country a good many miles of carriageway constructed upon this principle, the oldest and perhaps the best examples being those to be seen in the city of Liverpool. This pitch-macadam has long since passed out of the experimental stage, and if carried out in the proper manner with suitable material cannot result in anything but complete satisfaction.

Pitch-macadam is practically an elastic concrete, and has considerable power of distributing the weight of superimposed traffic.

It has, in common with ordinary tar concrete, the advantages of noiselessness, cleanliness, economy in maintenance and scavenging, but it has even over ordinary tar-macadam the following additional advantages:

It has greater density, firmness, durability and practical imperviousness.

It will be less expensive in maintenance, and can be scavenged with water from a hose pipe.

It can be made somewhat less slippery.

Traffic may pass over the road immediately it is completed without damaging it in any way.

It has, however, some disadvantages; among others a somewhat higher additional cost. Then there is the difficulty of keeping the aggregate dry before matrix is applied, which is more or less dependent upon weather conditions, but not entirely dependent, as it is quite possible to some extent to dry the aggregate by means of blow lamps before the grouting material is applied. This results in some measure of benefit, but very much better is it to get the aggregate spread dry, and once having it dry to keep it so by means of tarpaulins or other suitable means. Expense in rolling, unless favorable weather and prompt and ample supply of good matrix admit of making good headway and keeping the rollers fully employed, has also to be considered.

In some of the fine, broad, new streets which have been constructed by Mr. Brodie in Liverpool he has laid this pitch-macadam upon 5 ins. of concrete, not only on the sides of the roads, but also along and forming the tramway track.

The beneficial results to be obtained from the use of pitch-macadam were well demonstrated to the author recently when two sample bottles were exhibited. These represented material taken in the one case from an ordinary granite-macadam road and in the other case from the pitch-macadam road constructed of the like granite. The material in each case had been down for approximately the same period. In the case of the ordinary macadam road the material removed was carefully separated into layers of different sizes; but little of the original macadam remained, and all of that which did remain of approximately the original sizes had the arrises rounded off, and the sample was graded in various proportions through the size of beans, peas, grit and dust, and superimposed upon the ordinary dust was a considerable layer of exceedingly fine, floury dust, susceptible to the merest draft.

On the other hand, the pitch-macadam when restored to its original component parts of clean Welsh granite, clean silica sand and the tar compound showed the aggregate to have preserved the arrises and to be practically in as good condition as it was when first rolled into the road.

One needs very little plant, at least for an experimental commencement, for carrying on this class of work—merely a few portable sand-driers, tar-boilers, buckets on bogies, and a little loose plant. But it is confidently expected that the results of the adoption of this form of paving will justify the increase of plant

*Considerably condensed from an article in "The Surveyor and Municipal and County Engineer" (London, England) for April 22, 1910. Mr. Smith is the author of "Dustless Roads," favorably reviewed in our Engineering Literature Supplement for July 15, 1909.

necessary to execute work in large quantities with the greatest expedition.

The cost may be put down, if carried out in a small experimental way, as follows:

2 ins. thick.....2s. 9d. [57 cts.] per sq. yd.
2½ ins. thick.....4s. 0d. [97 cts.] per sq. yd.

These costs, however, can be reduced, particularly when the matrix can be prepared at a central depot and brought on the work in large quantities at frequent intervals, and when continuous work can be found for the steam roller and no loss of time caused through waiting for the pitch and oil to be properly tempered. The production of standard soft pitch which will require a known amount of boiling and eliminate a good deal of testing and ample boilers will also reduce the cost and result in much expedition, which, on account of broken weather, is much to be desired in this class of work. The costs will obviously be affected by the facilities for obtaining a local stone sufficiently good for the bottom coat and for obtaining a good, hard, tough granite for the wearing surface.

A uniform and satisfactory matrix is a sine quâ non, and deserves and requires very full and careful consideration; but it will be well to reserve the discussion of matrix for pitch-macadam for the time being and to deal with the whole question of standardization of matrix for both classes of tar-macadam together.

Tar-Concrete.

This may be prepared either manually or mechanically. The stage at which it is profitable to dispense with manual labor and to substitute mechanical power is one that will soon arrive with the adoption of this material.

MANUAL MIXING.—It will be necessary to keep the stone dry and, if possible, very slightly warm—not that the warmth is really required, but it will ensure the stone being perfectly dry. The stone can be perfectly well dried upon a wrought-iron plate supported upon brick piers, with coal or coke fires placed thereunder. This method is very crude and is not economical, but it can be adopted with satisfactory results where it is not wished to incur capital expenditure.

In circumstances which render it desirable to lay the road in one thickness it is satisfactory and economical to utilize the aggregate just as it leaves the breaker with the exclusion of dust.

Where it is advisable that the road should be constructed in two layers the bottom coat might consist of aggregate as it leaves the breaker, excluding that which would pass through a ½-in. screen, and be laid to finish 3½ ins. in thickness, and consist of the ½-in. chippings, separated from the bulk aggregate, to finish approximately ¾-in. thick. However the aggregate of whatever character and description used must be taken—after becoming dry naturally or otherwise—in known quantities, say, ½-yd., and placed upon mixing boards. Five gallons [6 U. S. gals.] of standard tar carefully brought to a certain temperature (say, approximately, 250° F.), and to a consistency to be tested by ready means, should then be poured on to it, the tarred stone being afterwards turned three times, as in the manner of mixing cement concrete, and tipped into the stock heap and—depending upon atmospheric temperatures—allowed to remain for about one month. The 5 gals. [6 U. S. gals.] mentioned for the ½-yd. measure will be insufficient for the top coat of chippings, and approximately 7 gals. [8.4 U. S. gals.] will need to be used per ½-yd. of this grade of aggregate.

Apart from the important question of a standard matrix, which will be dealt with later, two points are here worthy of consideration: The means of heating the tar, and the advantages or necessity of placing the tarred material to the stock heap for a period.

Firstly, as to heating: the author has a great preference for heating tar by steam coils arranged in such a manner that the safety valve of the boiler may be set to blow off at such a pressure as will correspond with the predetermined temperature required, thereby eliminating all risk of the tar being overheated by the ignorance or inattention of the man in charge of the tar boiler.

Beyond that very important factor of safety from overheating there is no advantage in steam heating over heating by fire direct if the boiler is in charge of a skilled and careful attendant, but a very short period of inattention to the boiler in the case of heating by fire direct may result disastrously; and, unfortunately, the fact of the tar being overheated or insufficiently heated may perhaps not come to light until the material has been spread and subjected to traffic for some short time.

Secondly as to the advantages of placing to the stock heap: it has frequently been alleged that great advantages are derived from leaving the tarred material in the stock heap for a long period. The author has had correspondence upon the subject of alleged patent rights existing for the storage of tarred material, and incidentally it may be remarked—as indicating the reprehensible tendency to hedge around the subject of bituminous-bound roads with patent rights and proprietary methods—that he has also had correspondence from America with reference to certain alleged infringement of patent rights on account of the preparation of tar-macadam with broken stones of "uneven sizes."

It is necessary in the case of hand mixing to leave the tarred material in a stock heap for some little time in order to allow the stone to become covered, for this result would not be obtained by hand-mixing save at enormous labor and expense, unless the tar were very much thinner than is essential for making good, tenacious tar-macadam, or without so heating the stone that the tar ran very freely, but on cooling lost its tenacity.

The manual mixing of tar-macadam is also a slow and laborious operation, and consequently a considerable store of this mixed material would be required ready for actual laying when the weather serves; but this necessity, of course, is to a great extent removed when one has mechanical means of producing up to 100 tons per day.

There is no doubt that there was a real necessity and is still considerable reason for storing when crude tar is used, as there is thereby a greater possibility of eliminating or reducing the inconsistencies inseparable from the use of such a varying article as ordinary crude tar, particularly when heated to various and inconstant degrees of temperature, as there would follow by the storing a certain amount of volatilization of various light oils and a certain blending of the various classes of tar employed.

It may be that there is some virtue in the stock heap even with standardized treatment, but it appears, at least for the time being, that the standardization of material and method removes the necessity for storage.

With hand-mixing, presuming the cost of aggregate to be 5s. 3d. [$1.28] per [long] ton, and the matrix to be 3d. per Imp. gal. [5 cts. per U. S. gal.], the inclusive cost per cubic yard of mixed material would be about 11s. [$2.67] per [long] ton.

MECHANICAL MIXING.—An engineer or surveyor to a council will already have a competent staff of men who are accustomed to the work of tar boiling, and there is nothing in the actual process which requires any particularly skilled labor. The degree of heating of the tar and the general knowledge of the requirements of particular road metal, and, in fact, the general supervisory work of tar-macadam preparation, should be in the hands of an experienced man, and this man, and this man alone, it would be necessary to train or introduce, and it would be necessary that he be paid a suitable wage in order to secure competent service. This man would, of course, be skilled in general paving works, so that it is merely a matter of adjustment of duties to find useful work for him to do during such times as it is inadvisable or impossible to prepare or lay either tar-macadam or pitch-macadam. At first these times may be of considerable extent, but as the process is developed it is not anticipated that there will be a big percentage of his time when he is not engaged either in the preparation or the actual laying of bituminous roads.

There are two main disadvantages in purchasing from contractors:

(1) The difficulty to prepare such a specification as would render comparative in all respects tenders that might be submitted from different parts of the country, and to ensure supplies being of a standard quality and in all respects up to the specified requirements.

(2) The obvious disadvantage that material which can be produced at the works for about 9s. per ton should have the dead-weight of 10s. per ton carriage from 120 miles, or 5s. per ton from a distance of 50 miles, or some considerable charge for freight when imported from any outside district.

It may be urged that, notwithstanding this heavy handicap, the wholesale manufacturers—if so they may be termed—will, on account of their large output, of their quarry facilities, or their tar products, or other peculiar facilities, be able to produce more cheaply than one can locally, even though one were provided with machinery.

This may be true to some extent, but certainly not in such a measure as to counteract at the most one moiety of the disadvantage at which the railway freight places it.

Even if there were no financial advantage, there would be certain other advantages which readily turn the scale in favor of mechanical mixing, and these are expedition, economy of storage space, and uniformity of mixing.

The presumed capital cost of a mixing installation of £750 [$3,460] may perhaps be considered a low one, but it is one that will completely cover a plant which the author is proposing at the present time to lay down, and it is generally similar to one which has been in operation with great success for the last ten or twelve years, and in connection with which there are no patent rights whatever. It is a "batch" mixer of very good type, and consists essentially of a trough, along the entire length of which is fixed a shaft, to which is attached a series of cast-iron blades placed at suitable angles. These blades are caused to revolve forward or backward by means of a steam winch. Any given amount of aggregate can be fed into this mixer, and to that amount can be added the requisite amount of tar matrix. Then the blades in motion turn the material up and down the trough mixer under full observation, so that immediately each particle of the aggregate is thoroughly coated with tar, the end of the trough is opened and a few revolutions of the axle discharge the contents into trucks or carts at the end, in such a way that there is no chance of the surplus tar causing clots in the tar-macadam. There can be added to this mixer, if necessary, a steam jacket, but it has not been found that any ill effects have accrued from the mixer under consideration not having been steam jacketed.

There is an advantage in being able to see the operation, but the chief disadvantage of this type is that it takes a considerable amount of power, the one under consideration being 14 ft. long, taking a charge of 1 cu. yd. of aggregate and requiring 10 HP. for driving. There is a considerable amount of wear on the blades and the bottom of the trough, particularly when granite is used.

It is, however, thought to be an advantage that this mixer can be obtained of any size, and could be manufactured locally.

Standardization of Matrix.

Interesting though it be, and indeed necessary for those who would go into the question of tar-bound road construction in a thorough manner, it is not possible in this instance to go fully into the question of tar production and the causes that lead to great variability, but it is accepted that there is great variation in the quality of tar. The matrix is the crux of the whole question of Bituminous-bound macadam roads, and brings one to the very important question of standardization of tar for paving purposes. [the author here describes his own tests for volatilization, viscosity, free carbon and adhesion.—Ed.]

DESCRIPTION OF TESTS APPLIED.—Comparatively recently the author had the opportunity elsewhere of describing certain means that he had taken to ensure an uniform and standard tar for paving purposes. Among other qualities which needed, in his opinion, to be considered were the following—viz., volatility, viscosity, power of adhesion to aggregate, specific gravity, free carbon and restriction and regulation of amount of distillate at various temperatures.

Tars of various descriptions and from various sources were taken in their crude state, were distilled to a comparatively uniform specific gravity and the residual soft pitches or tars of uniform specific gravity were subjected to various tests. For instance:

FOR VOLATILIZATION.—This appears to be an important one, for to a diminishing degree the constituents will be volatilizing from the day that the tar-macadam is first laid, and such volatilization cannot go on to a very great extent without impoverishing the surface and tending to disintegration.

For this test the various samples were taken and placed, in layers of ⅜-in. in thickness and not more, into open dishes and exposed to a temperature of 60° F. for one week, and then the percentage of loss by volatilization was ascertained. The residue from this test was then exposed to a temperature of 110° F. for one week, and the loss by volatilization at this temperature was recorded.

FOR VISCOSITY.—The necessity for a high viscosity must be readily apparent, although, of course, of itself its determination in tar-macadam would be valueless, for it would show that hard pitch, with its undesirable brittleness, would be the most advantageous fraction of tar to be utilized. However, in order to ascertain the comparative viscosity, samples of the aforementioned soft pitches were taken. The method of testing was as follows: The various descriptions of tar were put into small tins, about 2¼ ins. diameter by 1⅛ ins. deep, and these were placed in water contained in a tin tray about 14 × 14 ins., by 2 ins. deep, the water being heated by means of a Bunsen burner, and to prevent it becoming unevenly heated the burner was kept continually moving over the entire area of the tray bottom and the water continually stirred. Water lost by evaporation was constantly replenished, so that the same level was retained in the tray. Observations were taken when the temperature of the water was recorded at 62° (atmospheric temperature), 78°., 90°., 110° and 120° F. At each of the before-mentioned temperatures, circular copper disks, 1 in. in diameter and 5.715 grammes in weight, were laid flat upon the surface of the tar and the time required for the complete covering of the disk by the tar was recorded.

DETERMINATION OF FREE CARBON.—It must be obvious that a large percentage of free carbon is to be avoided, but a certain amount must necessarily be admissible. The samples previously referred to were subjected to the following test to ascertain the percentage of free carbon in the soft pitch—viz., ten grammes of the sample were successively extracted with hot benzine, alcohol and carbon bisulphide until the extractive liquid was no longer discolored. The residue was dried at 100° C. and weighed.

ADHESION.—For this important test the author devised a machine for ascertaining the tensional strain required to several briquettes that had been previously joined by the various samples of tar of which the adhesive properties were required to be known. The principal parts of this apparatus are: A spring balance with a large metal dial graduated in single ounces up to

50 lbs. (which would have been better increased to 100 lbs.) and fitted with a maximum hand; the jaws which hold the briquettes, one in each pair; the screw employed to pull them apart. The double briquette, jointed with the tar compound, is placed in the two pairs of jaws, which are made from stout brass castings and suitably shaped to receive it, and rests on rollers attached to the base which are provided to reduce the friction. When the briquettes are in position the wheel attached to the screw is turned so as to pull on them and thus on the spring balance, and this is continued until the briquettes break apart at the junction—the maximum force used being registered by the second pointer of the balance. First—there were made some hundreds of briquettes in a special mold, similar to an ordinary mold for making cement briquettes, save that it made half briquettes only, and made such briquettes with a cross sectional area of 4 sq. ins. These briquettes were made with cement and plaster of Paris, and great care was taken to get a perfectly uniform face. They were then dried for a considerable time. Then were taken various samples of soft pitch to be tested, and these were raised to a predetermined temperature, 250° F. A number of these half briquettes were then dipped into this heated tar, the surfaces being rubbed together for the expulsion, so far as possible, of any imprisoned air, and then firmly pressed together by hand pressure and stood in a vertical position to cool. For the testing of each particular sample there were taken four complete briquettes (8 halves) at a temperature of about 60° F., and the same number heated (before being dipped in the tar) to a temperature of 100° F. After they had cooled in a room of even temperature of approximately 55° F., the tar-jointed briquettes were broken as one would break ordinary cement briquettes, either upon the ordinary double level cement testing machine (for strains over 50 lbs.) or upon the special machine previously described. Where the tensional strength was considerable, the cement-testing machine answered the purpose quite well, but where the adhesion was small (under 50 lbs.) it needed to be recorded upon the more delicate instrument that was specially made. After the briquettes were broken and results recorded, the briquettes were carefully and evenly pressed together again by hand pressure (the tar being cold) and left for 24 hours and again tested. The complete results of these tests were tabulated and considered.

From the result of numerous distillations of crude tar and of the resultant soft pitches, and with the subsequent tests for volatilization, viscosity, etc., an attempt was made to lay down certain standards.

The question of standardization depends greatly upon local requirements, but generally speaking, it appeared to the author that there are required to meet the varying climatic conditions and to meet methods and materials of construction for tar concrete, at least two standards of matrix, which may be described as "moderate" and "heavy." The times and opportunities for the use of each particular grade must be more or less a matter to be decided locally.

Suggested Standards for Matrix for Tar Concrete.

It is suggested that the 'heavy" grade tar should comply with the following specification:

The tar or soft pitch shall be produced by the distillation of tar derived exclusively from bituminous coal, and must contain no impurities.

The specific gravity, as determined by a tar specific gravity bottle, should be approximately 1.220 at 15.5° C. On distillation (the bulb of the thermometer being placed in the vapor at a point where it enters the side tube of the distillation flask) it must not yield more than 10% of distillate below 289° C., and not more than 25% below 350° C.

The free carbon determined as specified in the tests described must not exceed 10% by weight. When thoroughly mixed with water and kept for some time at a temperature of 110° F., the water shall contain not more than 23 gr. per gal. of total solids. On exposure to an atmosphere of approximately 60° F. for one week, in a layer not exceeding ¾-in. thickness, the tar must not lose more than 1.5% of its weight, and the residue from this test must not lose more than 3.5% of its weight on exposure to a temperature of 110° F. for one week.

Its viscosity shall be such that when tested in the manner described the disk shall not be covered in a less time at 60° F. than 5½ minutes, nor in less than 10 seconds at 110° F.

There shall be recorded an adhesive strength upon the 4-sq. in. ends of the briquette, from experiment conducted in manner described, a result of at least 75 lbs. with the cool briquette, and the re-adhesion shall comply with the like test.

For the "moderate," tar there must be the following amendments from the figures specified for the "heavy" grade:

The specific gravity to be reduced from 1.22 to 1.195; there must be not more distillate below 350° C. than 35% as against 25%; the volatilization tests to be 2% for the first week and 8% for the second week, as against 1.5% and 3.5% for the "heavy" grade. The viscosities to be 30 seconds and 2 seconds at the two temperatures of 60° and 110° F. The adhesive strength to be reduced in each case from 75 lbs. to 45 lbs., but otherwise the specification is to remain the same.

Liverpool Standard for Matrix Pitch-Macadam.

For "pitch-macadam" a much heavier matrix is desirable and permissible, and in this connection the author begs to quote from "Dustless Roads," where the matrix for "pitch-macadam" is fully dealt with as follows:

The specification for the matrix as prepared by Mr. John A. Brodie, City Engineer, Liverpool, who was, so far as the author knows, the first to seriously and scientifically standardize the matrix, is as follows:

PITCH.—(1) The pitch must yield no matter volatile below 270° C. when subjected to dry distillation, and its total volatile organic matter must not fall below 30%.

(2) It must not contain more than 80% of its weight of matter insoluble in petroleum spirit of 0.700 specific gravity (boiling), and must be free from extraneous matter such as sand and grit.

(3) It must twist fairly after immersion for two minutes in water at 60° F., but not under 55° F.

CREOSOTE OIL.—(1) The creosote oil shall be obtained exclusively by the distillation of coal tar and not more than 6% shall re-distill below 240° C.

(2) The oil as obtained by the distillation of coal tar shall not be treated in any way, either by the addition of any coal tar product or by the extraction of any of its constituents, excepting such extraction as may be necessary to comply with the following requirements.

(3) It shall contain no solid matter at 15° C., and shall have a specific gravity of not less than 1.060 (taking water as 1.000 at 15° C.).

(4) It must contain not less than 25% of its constituents that do not distill over below 320° C., and the 75% which does distill over below 320° C. shall contain 10% of tar acids to be extracted by soda, specific gravity 1.125 (water 1.000).

The hot pitch and oil shall be tempered in a pitch boiler until it complies with the following practical tests: The mixture, when cooled in water, at 60° F., should stretch at least 3 ft. before breaking; and the threads so formed should pull out very finely indeed. It should also, when doubled into a length of about 1 ft., bear hitting hard on an iron or stone surface without showing sign of cracking.

It may not be out of place if the author at this point briefly indicates the reasons for those specified requirements.

Mr. Brodie had found that the tar distillers and merchants were not supplying him with a thoroughly good paving pitch, and what was worse, it was not uniformly mediocre, but was variable in a very high degree, so that he, very wisely as the author thinks, worked from an excellent pitch which he had procured from some paving taken up after twenty years' wear, which pitch was found to be practically as fresh, tenacious, and full of life as when first laid, and he consequently worked back from this time-proven sample and practically determined his standard from analysis of it.

Tar Specification as Suggested By the Bureau of Research of New York State.

Certain questions may, and probably will, arise in working to, extending or improving tar standards.

The very full, complete and scientific manner in which the State Departments of America standardize their bituminous material for asphalt work should be an object-lesson to British road engineers, and at least the State of New York have now adopted a standard for tar to be used in connection with their bituminous-bound roads. Their standard reads as follows:

(1) The tar shall contain no water and not more than 0.5% of mineral matter or dirt.

(2) It shall be uniform in character, appearance and viscosity.

(3) It shall not contain over 15% of water soluble materials.

(4) It shall have a specific gravity between 1.20 and 1.29 at 25° C.

(5) It shall contain no body that distills at a lower temperature than 225° C.; not over 9% by weight shall distill below 270° C., and it shall contain at least 60% by weight of pitch remaining after all bodies up to 360° C. have been distilled.

(6) On extraction with benzol it shall contain from 12 to 21% free carbon.

(7) A ½-in. roll of the crude material, 6 ins. in length, cooled to a temperature of 15° C., shall permit a torsional test of at least three complete turns without breaking or cracking, and shall stretch at least 3 ft., forming at the center a very fine thread before rupture occurs.

This had been submitted to the author by the State of New York, and certain queries have been submitted to him by them and by the American Tar Co., there being a difference of opinion between these two bodies as to the practicability of the standard proposed to be adopted.

In consideration of the questions submitted the author collaborated with Mr. Joseph Race, F. I. C., of Burnley, whose assistance he has previously acknowledged and for whose further assistance in this case he is greatly indebted.

A few comments upon this American specification may not be out of place.

Nos. 1 and 2.—These seem to be in order.

No. 3.—The allowance of 1.5% of water soluble materials appears to be somewhat generous to the tar distiller, and the figure might with advantage be made rather more stringent by reducing it to about 0.5%. There ought to be some statement as to the manner in which this test should be applied, especially as to the amount of water to be used for a given volume of tar, and also the temperature at which the test is to be made.

No. 4.—This clause appears to the author to be somewhat loose. The limit allowed is much too great. There is such a considerable physical difference between tar with a specific gravity of 1.29 and one with a specific gravity of 1.20, and it is thought to be better that there should be three grades or standards between 1.2 and 1.29, each having over and above the distill[illegible] requirements certain physical requirements to com[illegible] with, each arranged to be suitable to a particular [illegible] of work.

No. 5.—This seems to be generally upon all fo[illegible] with the standard which the author suggests.

No. 6.—This clause seems to be open to con[illegible]able discussion, and it is thought that additional [illegible]arch will be required. The author preferred to l[illegible] the clause restricting the amount of free carbon, [illegible] the restricted amount was suggested at 10% by weig[illegible]

The question now arising is as to the benefit t[illegible] will be derived from at least 12% of free carbon. Is [illegible]ne-ficial in itself or is it included in order to [illegible]vide against some contingency or possible dilution? [illegible] does not seem probable that free carbon is desirable i[illegible] self, as in compression or torsion it would disintegra[illegible] to a powder and render the matrix less homogeneous. Tests for free carbon with tar from various sources r[illegible]lted as follows:

Description of tar.	Specific gravity.	Percentage of free carbon.
Tarmite	1.180	10.[illegible]
Blast furnace	1.195	10.[illegible]
Distilled (North Lancashire)	1.195	11.[illegible]
Coke oven (Wigan)	1.210	14.[illegible]
Carburetted water gas	1.210	0.[illegible]
Carburetted water gas	1.226	0.23
Coal gas (Burnley)	1.215	12.4
Coal gas (Burnley)	1.231	13.[illegible]
Tarvia	1.245	11.[illegible]

From this it may appear that the reason for the American desire for the 12% of free carbon is to exclude all water-gas tar, but whether or not the soft pitches resulting from carburetted water gas tar should necessarily be excluded is open to very grave doubt.

No. 7.—This simple physical test is one that does not need comment.

Concluding Remarks Upon Tar Standardization.

It must be realized sooner or later—the sooner the better—that the standardizing of materials for road construction must emanate from municipal engineers and surveyors, to whom and to whom alone the public need look for improvements in road construction.

Tar distillers may assist us up to a certain point, but they are tar distillers and commercial men first, and may not realize that their full-hearted cooperation in this matter would ultimately result in their decided benefit.

There will be a difficulty in causing them to realize—if it is agreed that they will have to realize—the necessity for any more complete specification than that of a certain specific gravity for tar; and, while undesirable that he should be encumbered with any further details than are essential, it may be necessary for the municipal engineer to establish his own distillation plant.

That coal tar alone is necessarily the best and most profitable matrix to employ in tar-macadam construction is by no means put forward as a dogma. The author has for some time considered what beneficial results might accrue from the blending of coal gas or other similar tar with a proportion of natural or other bitumen. The extent to which beneficial results—if any, for certain chemical questions are opened up—will accrue he, not having had opportunity for experiment, is not able to say, but it does suggest itself to him that one could with advantage to oneself and benefit to one's professional brethren carry out a series of tests on the lines that he has suggested, or on any improved lines that may suggest themselves to others, using a stock distilled tar with various proportions of bitumen of various kinds added; then, if the beneficial results which might reasonably be expected should be confirmed it would resolve itself into a question of preparing such a blend—where something better than tar is required—as would be the best compromise between quality and cost.

The municipal engineer in Britain has not the state nor any Government subsidized department to fall back upon for work of this kind, and, rightly or wrongly, it is left to him to work out his own salvation in these respects.

In determining matters of this nature it must be obvious that the addition to the staff of the borough engineer, where the size of his department and the scope of his work will warrant it, of a chemist assistant is highly desirable. Apart from such experimental work as is suggested in this case, for which the chemist is eminently fitted, and which requires to bring it to a successful issue considerable care, concentration of thought and ample time, a chemist could assist the municipal engineer in testing cement, oils, etc., and in analyzing sewage, water, air, and indeed in numerous ways. Where, however, it is not possible to employ a full-time chemist upon one's staff, it is desirable wherever possible that a chemist's assistance or cooperation be obtained in this matter, as it has so beneficially been obtained in other matters—such as the purification of sewage—in which the municipal engineer is so vitally interested.

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With no other intention than that of bringing before our readers an interesting variety of articles, the contents of the present number deal with important engineering works and discussions in widely separated countries, and with the creations of the engineer of more than two thousand years ago, as well as those of the present day. Some of the most notable of these articles have seemed to call for the editorial comment that follows, either to correlate the subject-matter with our own country and time or to direct the attention of the reader to points of special interest. For the convenience of our readers, we have combined in one article, abstracts of and editorial comments on several papers dealing with the Electrification of Steam Railways, presented a few weeks ago at the International Railway Conference at Berne. That our current issue is by no means wholly devoted to foreign engineering practice and discussions and to ancient engineering works, may be seen by referring to the very practical article on Blasting Precautions, which occupies a number of the columns which precede this page, as well as to the Economic Study of Railway Ties, and various shorter articles and notes. We make no apology for the large amount of space devoted to other countries and times. The broad-minded engineer learns from his professional brethren the world over, and his interests are by no means confined to the engineering works of the present day.

Rarely does an engineer have so good an opportunity to study the details of engineering works twenty centuries old as is afforded by the article on ancient Ceylon tanks or reservoirs, which has leading place in this issue. The outlet gate chambers there figured are of particular interest. They are remarkably like recent structures built for like purposes. The whole article abounds with interesting technical and historical information regarding engineering work in times and in a land far distant. The fact that some of these old embankments and reservoirs are still in use, and the comparisons drawn by the author between them and modern works, add to the interest and value of the article, particularly in view of the fact that Mr. Bligh is also the author of "Practical Irrigation Works," which is one of the best of the recent books on irrigation engineering.

In every populous civilized country on the globe to-day there is no end of experimentation and waste connected with the search for durable and dustless road materials, which can be laid down and maintained within the financial means of the moderate-sized town and well-traveled rural districts. What the road of the future will be we cannot say. Just now, various forms of bituminous-bound broken-stone roads seem to be displacing the time-honored dust-and-water-bound macadam.

On account of its relative cheapness and the large quantities readily available on every hand, tar has the leading place among bituminous road binders. Unfortunately, no two crude by-product tars are alike, and we have not yet learned just what the standard for road tars should be under all conditions, nor how they may best be incorporated with the broken stone which they are to hold together. Consequently, no end of experiments are being made with all sorts of tars and methods of construction. Few of these experiments are being made under intelligent, impartial direction; that is, by men possessing technical training and skill, whose first aim is to secure the best road at the least money, and who have no interest, direct or indirect, in one bituminous binder over another. As a result, thousands of dollars are being wasted on every hand, and thousands of "horrible examples" of road construction are scattered over the country.

The great variations in tar and in the methods of using it, combined with the numerous commercial interests now in the field to exploit one or both, make standardization imperative. Much work to that end is being done both here and abroad. Among the foreign workers in this field none is more worthy of a hearing than Mr. T. Walker Smith, City Engineer of Edinburgh. We therefore take pleasure in directing attention to the lengthy extracts from a carefully prepared paper by Mr. Smith, which we print elsewhere in this issue.

It has been the good fortune of nearly all American cities to dispose of their sewage without recourse to pumping, and scarcely a one of our cities of considerable size has yet been forced by natural conditions or by law to purify its sewage. In England the conditions are far different. Pumping and purification often go hand-in-hand. In fact, the natural and legal conditions which so often made purification imperative in England, frequently made pumping unavoidable, particularly during the long period, now happily past, when the central authorities made land treatment an essential part of every sewage works for an inland city.

The most extreme instance of combined pumping and sewage purification against natural obstacles which has ever come to our attention is afforded by Leicester, England. That city now pumps its sewage 160 to 180 ft., then settles it, applies it to contact beds and again settles it, then pumps it again and gives it from one to three applications to the heavy clay land—which comprises the large sewage farm which formerly afforded the sole means of purification.

Why Leicester adopted so complex and costly a plan of getting rid of its sewage is explained elsewhere in this issue. Presumably, some other method would be adopted if the problem were to be taken up with a free hand in the light of the present day.

Without for a moment raising any question as to the engineering ability and judgment shown for years past by the eminent city engineer of Leicester, whom we believe to be one of the ablest of the many able municipal engineers of Great Britain, it does seem to an outsider as though money might have been saved to the municipal treasury of Leicester by selling its sewage farm and building its new settling tanks and bacteria beds somewhere down in the valley. Of course, this may have been wholly impracticable. Perhaps no valley site for sewage works was available within reasonable distance. Possibly a greater bar, at that time, was the compulsory land-disposal requirement of the Local Government Board, since done away with or reduced to an alternative condition, thanks to the Royal Commission on Sewage Disposal.

All speculations aside, Mr. Mawbey met the hard conditions which confronted him in a way that does credit to the engineering profession. The story of his achievement, which we have condensed from his own words, can scarcely fail to interest a large percentage of our readers, regardless of their special interest or lack of interest in sewage disposal problems.

It is hard to repress feelings of shame and hostile resentment at the testimony given before a legislative investigation committee in New York last week, which indicates that the state street railway association maintained close secret relations with members of the Legislature, contributed large sums to party campaign funds, and dispensed free-handed charity to heads of committees or other important members of the State Legislature. Such extensive efforts to "influence" the government of the state are alarming enough to every citizen as citizens. To the engineer, however, they are of specially bad color, because many industrial associations like the one in question have tried to occupy a position among engineering societies, or at least have claimed to rank as semi-technical organizations. The clean record of the engineering profession in its societies is in danger of being besmirched by even remote fellowship with the instruments of legislative subsidizing.

Of course there is a very sharply drawn line between societies of engineers and commercial associations of industrial interests, even when the latter are semi-technical in their work or nature. But there has been a tendency in recent years to magnify the technical importance of such associations, and in some cases even they have established subordinate engineering societies and maintained them under their control. As water can rise no higher than its source, so also a subordinate society of this kind will not bear a better stamp than its creator and controller. In considering a technical society, therefore, it is of vital importance in every case to inquire whether it is an independent society of professional men or whether, by the nature of its control or in its objects and methods, it stands on a different, lower, level.

The testimony above referred to contained an interesting illustration, by the way, of how some of the generous donators themselves looked upon their work. What we will quote is in point also, because coming from the well-known ex-president of the remarkable street-railway combine of New York City, Mr. H. H. Vreeland. Incidentally, he was for years president of the New York Railroad Club, a body whose membership has a large proportion of engineering officials. Mr. Vreeland was asked (we quote the report in the New York "Sun") whether he had been an officer of the Street Railway Association of the State of New York, and said:

> As president of the Metropolitan Street Railway Company I was [and later in explanation of this form of statement:] I am making a distinction between H. H. Vreeland the individual and H. H. Vreeland representing the Metropolitan Street Railway Company.

The implied distinction is not hard to understand, in view of the testimony previously brought out to trace the flow of money from agents of the Street Railway Association into the hands of legislators, chairmen of committees on franchises and other pertinent subjects. The company could easily bear the extra moral burden, for Mr. Vreeland testified that the Metropolitan for many years made contributions to political parties so generously and broadly as to induce him to say, on the question of who was remembered in these donations:

> Well I should say, at least from my experience covering a number of years, that it was everybody that ever ran for office.

The Electrification of Steam Railways.

Is the electric locomotive eventually to replace the steam locomotive in general railway service? Would such a change be to the interest of the public? If all lines cannot be or ought not to be electrified, then on what lines or classes of lines should the change be made? Under what conditions may the public be justified in compelling by law or ordinance a change from steam to electricity?

Questions like these are frequently asked today by the public. Among engineers and railway officers, also, while the opinions as to electrification are much less sanguine than a few years ago, one frequently hears questions such as those set down above.

At two great international engineering meetings this summer the subject of steam railway electrification claimed a large share of attention. At the International Railway Congress at Berne, four reports on this subject were presented by engineers of four nations, Germany, Austria-Hungary, Switzerland and the United States. At the joint meeting of the British and American Mechanical Engineering Societies at London, on July 29, five papers on this subject were presented, three by Americans and two by Englishmen.

All of these authors are engineers of high standing, particularly well able to speak authoritatively in answer to such questions as those which we have placed at the head of this article. It is of interest, therefore, to study these several papers and see what light they shed on the questions which we have raised. It must be said, however, that taking these papers as a whole, they deal rather with the merits of particular systems of electrification than the relative merits of electricity and its older competitor. Furthermore, the papers are chiefly devoted to recording facts and the authors are usually chary of stating general conclusions.

Taking up first the Railway Congress papers, the situation in Germany was set forth in a paper by Dr. Gleichman, State Councillor of the Bavarian Board of Works. The paper opened with the remark that of the state railways of Germany, the Prussian-Hessian, the Baden and the Bavarian administrations have given special study to the question "whether, and under what conditions electric operation may profitably replace steam operation on main line railways."

These three administrations, according to Dr. Gleichman, favor the electrification of steam railways as a general proposition. Nevertheless, they are proceeding with much caution in the actual introduction of electricity. So far all that has been done in Prussia is to electrify two suburban railways, one at Berlin and the other at Hamburg. Estimates have been made, however, and have resulted favorably, for electrifying the main lines between Magdeburg, Halle, and Leipzig, "with the object of utilizing the neighboring beds of cheap inferior lignite" in the power stations. Even here the project is to be undertaken on a modest scale at first, a 16-mile section from Dessau to Bitterfeld being all that is now planned. The Prussian Chamber of Deputies has been asked to sanction a loan to electrify this short section.

The Baden state railways have decided to adopt electric locomotives on the Wiesental Railway, which has a total length of 31 miles. The reason electricity was adopted here was the presence of a convenient water power. Current is to be purchased from the company which has developed this power, at the rate of $30,000 per annum for a uniform supply of 1,040 KW., and the electric locomotives are now being built. The estimates indicate that the cost per KW.-hr. at the power station will be 0.36-ct. The Wiesental Railway has a traffic of some 60 passenger trains and 22 freight trains daily.

The Bavarian State Railway, to quote Dr. Gleichman, "considers the utilization of water powers for the electric operation of railways combined with the supply of electric power for other purposes as an important task of great economic importance." It also is about to undertake the electrification of a short line, located near Salzburg, to utilize water power. The total length of the line to be altered is 25 miles and the traffic is chiefly passenger, there being only four freight trains per day against 36 passenger trains.

Among the questions asked by the Railway Congress Organization was: "What cost could be paid per KW.-hr. for electric current and still leave electric traction no more expensive than steam traction?" The answer to this in the case of the Salzburg Railway, (the answer being made, of course, from the estimates, since the work is not yet carried out) was 1.16 cts. Whether this figure takes into account the difference in capital and depreciation charges on electric and on steam is not clear.

It will be seen, therefore, that the German railway administration are proceeding very cautiously in the actual substitution of electric traction for steam. Dr. Gleichman says, indeed, that the managers of all these railways named believe that a greater extension of electric operation would be justifiable ("for it can compete with steam operation from both the technical and the economic point of view"). The doubts of the military authorities, however, form a material obstacle to the further adoption of electricity. While it is not so stated, it may be surmised that the military authorities are doubtful of electric operation on account of the facility with which an enemy, even a single spy, could put a whole railway out of service by destroying the transmission lines at some point.

Turning now to the report from Austria, this was prepared by Dr. Arthur Hruschka, who is secretary of the special commission organized by the Austrian State Railways Administration "to study the present and future technical and economic aspects of electric traction on railways with a total extent of 2,697 miles, within the range of the available water powers." This commission has not yet completed its work but Dr. Hruschka gives a summary of what the commission has accomplished to the present time.

There are two classes of railways, he says, which may profitably be converted to electric operation: First, those where the change is made for certain technical advantages, such as abolition of smoke, operation of frequent train service, increase of traffic, etc. The second class is where the electric operation can show a saving over steam in total operating expenses. In order that this result shall obtain there must be a sufficiently low price for electric current, a sufficiently heavy traffic and a sufficiently large energy consumption due, for example, to steep grades or frequent stops.

In that part of Austria north of the Danube, there are plentiful supplies of good coal, but no water powers of importance. South of the Danube, however, it is necessary to use local coal of poor quality or else expensive coal imported from England or elsewhere. Here, also, there is ample water power available, steep grades are the rule and there are many tunnels. The traffic is light on some lines and on others fairly heavy.

In Hungary there is comparatively a small mileage on which similar favorable conditions for electric operation exist, but the railway administration has made careful investigations as to the locations where electricity could profitably be adopted.

The Südbahn Co. has also investigated the electrification of two of its lines where water powers are available.

The work of the Austrian Commission on electrification has progressed so far that detailed plans are being prepared for the conversion of lines aggregating 621 miles. The Trieste-Opcina line and the Arlberg Ry. will be first undertaken. It is already known which of the available water powers will be utilized and the State Railway administration plans to secure options from prospective water-power companies for the supply of current. "Generally the supply of current for railway use will be combined with its supply for power and lighting, so as to obtain the most economical result." It is planned, also, to supplement the water-power stations generally with steam or gas-engine driven machinery for reserve and emergency. One statement in Dr. Hruschka's summary is specially significant: "In all cases the ultimate financial result will depend on the maintenance and renewal costs."

The Railway Congress paper summarizing American experience as to electrification is by Mr. Geo. Gibbs, M. Am. Soc. C. E., who has been prominently identified with the work of electrification carried out on the Pennsylvania R. R., particularly the Long Island lines and the road from Camden to Atlantic City. Mr. Gibbs' paper (a large part of which was reprinted in our issue of March 31, 1910), dealt most largely with these, but gave also an excellent historical review and summary of all that has been done in the United States to the present time in electrification.

One searches Mr. Gibbs' paper in vain for a categorical answer to the questions placed at the head of this article. By reading between the lines, however, some interesting facts are discussed. Discussing the cost of electrification, Mr. Gibbs emphasizes the idea that each installation must be dealt with by itself as a separate engineering problem. He says that "cost figures for one situation will generally not apply to another, even if the other road is of similar character." Continuing:

> Generally speaking, the cost of converting a steam railroad to electric traction is very high under American conditions. Taking into account the changes in the physical property and equipment it will at times mean a doubling of the existing capitalization.
>
> * * * Railway managers, although watching with interest the pioneer installations of electric operation on steam roads have not been anxious to duplicate experiments in advance of a demonstration of the results, and are awaiting this demonstration.

Of more significance still are the figures given by Mr. Gibbs comparing the operating expenses per car mile by electricity and by steam on the Long Island R. R. and on the West Jersey & Seashore R. R. (the line to Atlantic City) for the year 1908. In that year the average operating cost per car mile on the Long Island R. R. was 17.80 cts. per car mile for electric trains and 27.95 cts. for steam trains. On the West Jersey & Seashore R. R. the electric trains cost 20.46 cts. per car mile against 22.30 cts. per car mile for steam trains. The difference in the showing on the two roads is due first to the different service. The Long Island traffic is practically a suburban service with frequent stops. The average run is only 2½ miles between stops, even on the so-called express trains. On the West Jersey & Seashore R. R. about one-third the train mileage is made with about 25 miles between stops. Further, the Long Island steam trains were of about the same length as the electric trains, while on the West Jersey road the steam trains averaged twice the length of the electric. It should also be noted that the Long Island cars averaged only 36 tons weight, while the West Jersey cars weighed 47 tons. To quote Mr. Gibbs:

> In other words the Long Island installation may be considered purely local service in a densely populated district, whereas the West Jersey service approximates main line railway conditions with long runs.

But in making this comparison between the car mile costs with steam and with electric traction, bear in mind that these are *operating costs* alone. They include, Mr. Gibbs explicitly states, "all operating expenses of the railway." Evidently then they do *not* include either interest or depreciation on the heavy investment made to electrify these two roads.

The electric railway advocate is fond of leaving this charge to be provided for by the increase of traffic which he claims follows the adoption of electric traction; but on the Atlantic City line, at least, it would be difficult to support any such claim. The steam trains to Atlantic City are quite as popular with the public as the electric trains and make faster time. Even on the Long Island R. R., it would be difficult to say how much of the traffic growth since electrification is due to that change and how much is due to the steady settlement of suburban territory which is overwhelming with passengers other roads at New York City which run steam trains only.

The conclusion is inevitable, then, that on the West Jersey road, which as Mr. Gibbs truly says, fairly represents main line conditions, electricity costs practically as much as steam for operation and yields no economies worth mention to meet

interest and depreciation charges on the large outlay for electrification. It is only under the suburban traffic conditions of the Long Island R. R. that electricity shows a material saving over steam, and even here it is a question whether the saving will any more than cover the capital charges.

It should be stated here, however, that other considerations than merely the direct saving on the Long Island road alone dictated the introduction of electricity there. We are calling attention to these facts merely to shed light on the broad questions which we have placed at the head of this article.

And now let us turn to the papers at the International meeting in London.

Of the two papers by Englishmen, that by Mr. F. W. Carter, of Rugby, was entitled "Electrification of Suburban Railways" and the following quotation well summarizes his opinion on the subject under discussion:

> There appears little prospect of general electrification of the railways of this country, as no advantage is apparent which would in any way justify the expense. It is only in the case of heavy suburban service that there is prospect of commercial advantage accruing from electrification, and whilst there may be other local opportunities for electrical working, there is at present no indication that the steam locomotive can be superseded with advantage for ordinary main-line work.

Mr. Carter's paper was a record of English experience in the electrification of suburban lines, laid down to aid the engineer in the process of investigating whether or not a proposed electrification would be advisable. "Even in heavy suburban service," said Mr. Carter, "the commercial advantage of electric traction should not be taken for granted for the margin in favor of electrification is by no means overwheming."

The paper by Mr. H. M. Hobart, of London, entitled "The Cost of Electric Suburban Trains," while largely devoted to an advocacy of the direct current system rather than the single-phase, was in general agreement with the above quotation from Mr. Carter. Mr. Hobart said:

> For not applying electrical methods to other railway traffic than suburban there is, so far as relates to Great Britain, the best of all reasons, namely that steam is, at present, in almost all instances, more economical. In countries where coal is scarce and water-power abundant, as, for instance, in Sweden, Italy, and Switzerland, the general electrification of the railways may be a thoroughly sound proposition, but the distinction between the conditions in Britain and in the countries cited is obvious.

Turning now to the American papers at the London meeting, that by Mr. Geo. Westinghouse was fully abstracted and commented upon in our issue of July 7. It will be remembered that Mr. Westinghouse urged the adoption of a standard system of electrification on the ground that the general substitution of electricity for steam was a certainty of the future. He declared it to be his belief that "the increased capacity of a railway and its stations, the economies of operation and other advantages will bring about gradually the systematic electrification of steam railways." His paper was chiefly devoted, however, to urging the merits of the single-phase system in comparison with the continuous-current system, and into this we need not now enter.

The paper by Mr. W. B. Potter, of the General Electric Co., on the other hand, presented the opposite point of view from that taken by Mr. Westinghouse as to the relative merits of the two chief competing systems, but contained nothing bearing directly on the problems we are here considering.

The third paper, by Mr. L. R. Pomeroy, bore directly on the comparative merits of steam and electricity and the following quotation is, perhaps, most significant of Mr. Pomeroy's attitude:

> The only cases where electric operation is commercially justifiable is in congested local passenger situations, where the conditions closely approach those of a "moving sidewalk"; and the records show that these cases *have been profitable only where a large increase in business has been realized.* [Italics ours].

From the above brief summary of these several papers it will be apparent that the authors, on the whole, are in fair agreement. If we except the very general prophecy which Mr. Westinghouse makes, all agree that electrification of steam railways can only be carried out with profit under special conditions. In other words, there is absolutely no reason to suppose that the steam locomotive, developed as it has been by the evolution of nearly a century to one of the most efficient and reliable machines in the whole range of engineering, is doomed for extinction because electricity has now made available a different method of performing its work.

It must not be forgotten that of the total railway mileage of the world, by far the greater part is made up of lines of light traffic. The trunk lines and the lines in densely populated districts form probably not more than a quarter or at most a third of the total mileage. On all these lines of thin traffic, the steam locomotive or at least some form of independent motor, not tied to a power station, is from the nature of the case more economical than any electric system with its necessarily heavy cost of installation. In fact, the problem on most of these light traffic lines, comprising as we have seen the larger part of the world's railway mileage, is how to earn a fair income on present capitalization. The advantages which can be gained with electricity in a densely populated district do not obtain in the regions where most of these light traffic lines are located. More frequent train service, for example, adds inevitably to operating expenses and can increase travel but little where population is sparse. In fact, railways of this class as a rule, rely on freight traffic rather than passengers for their income, and it is needless to say that for economical freight movement, the fewer the trains and the heavier their loading the lower the operating cost.

Mr. Gibbs states what is generally well known when he says that in the United States at the present time railway managers are not inclined to proceed further with the substitution of electricity for steam save for locations where special conditions such as the presence of long tunnels render such a change advisable. In England, as shown by the papers read at London, there is a tendency to look with favor on the electrification of some lines of heavy suburban traffic; but here in the United States there seems less readiness to undertake such transformations than a few years ago. The enormous outlay which the work done at New York City has involved (not all, it is true, chargeable to electrification) tends to make railway companies pause before embarking on similar enterprises.

Mr. Gibbs says truly that electrification of steam railways under American conditions involves a very heavy expense. One reason for this is the heavy weight of American trains compared with European. It is manifest that conditions are more favorable for the distribution of electricity from a central power house to a large number of motors of moderate size than to a small number of very large motors.

The electricity advocates are accustomed to urge that electricity makes possible the operation of smaller train units. But while this argument has a certain force it does not do to carry it too far. Even with electric operation an increased number of trains means increased operating expense. Further, the traffic capacity of a railway depends directly on the length of the trains that can be moved. In the rush hours of morning and evening, when the terminal lines of many railways must have trains moved over them as close together as safety will permit, electricity must be capable of moving trains at least as heavy as steam locomotives are now handling or it is not in the running. Admittedly, electric locomotives can be and have been built of the necessary power; but the point is that this involves heavy expense and thus electricity is handicapped here as compared with conditions in Europe.

As one studies the various arguments brought forward by electric engineers for the superiority of electric traction to the steam locomotive one is impressed that there is a lack of understanding of the limitations which traffic and operating conditions set in actual railway operations. Mr. Pomeroy, in his paper, gave one example of this in the claims made that the electric locomotive can perform continuous service throughout the 24 hours while the steam machine, according to figures from actual railway service, is hauling trains only 28% of the time. Mr. Pomeroy showed that, by actual test, for fully half of the 24 hours the steam locomotive is idle because of traffic and operating conditions, so that this percentage of idle time would apply the same to an electric locomotive as to steam.

Another example is the claim that electric cars and locomotives cause less wear and tear on the track because of the much talked about "hammer-blow" of the steam locomotive. The technical literature of the past 15 years is full of such claims, and estimates have even been gravely put forward of the saving which should be credited to the electric system on this account.

But experience has fully demonstrated now that electric cars and locomotives are more severe on track than even the heaviest steam locomotives. The weight of the car motors only partially spring supported and the low center of gravity of many of the electric locomotives have proved much more severe on the track than the much-talked of "hammer-blow," which in a properly designed steam locomotive is of no practical importance.

It is a remarkable fact, too, that in the latest designs of electric locomotives for high speed, both in the United States and on the Continent of Europe, a return has been made to the side-rod system of transmitting the power to the driving wheels which has always been used on steam locomotives, and with this several other stereotyped claims for the mechanical superiority of the electric machine over its older rival have fallen to the ground. But we need not multiply examples. We only wish to show that the elaborate claims for the advantages of electricity over steam with which technical literature has been so long filled, need to be tested in the light of practical experience.

Let it be understood that we are not writing in defence of the steam system or in criticism of the electric system. What we urge is, that comparisons be made on the basis of demonstrated facts and experience; and it behooves engineers, certainly, to make no claims for or against either system that experience will not bear out.

Again we would emphasize what was well brought out by several of the authors referred to above, that each electrification scheme is an engineering problem by itself. Particularly is it true that experience in one country is no criterion as to practice in another. Austria has the largest electrification scheme planned for any country in the world; but it is peculiar local conditions that have made it feasible, and in northern Austria, where these conditions do not exist, there is no thought of changing from steam to electricity.

One can readily understand how in the Alps, where locomotive coal is exceedingly costly, unlimited water power is available, grades are steep, tunnels are frequent, trains are light compared with American practice, and traffic is chiefly passenger—one can readily understand how under such conditions electrification might show a good return on the invested capital. But wholesale electrification in Southern Austria has no bearing on our problems in the United States.

We doubt not that this fact is self-evident to engineers, but it is not understood, unfortunately, by the general public. The public knows only that electricity has replaced steam at such and such places. It has no appreciation of the difference in conditions that so greatly affect the problems. There is danger, we believe, that American railways may be forced by state or municipal action into the undertaking of electrification work that sound enginering could not sanction. And on this point we cannot do better than to quote again from Mr. Pomeroy's paper.

> The idea is all too prevalent with the public and even with some of the bodies that have been given legal power of supervision over railway companies that any expenditure which can be forced upon the railway companies is just so much gain for the public. Never was there a more absolute fallacy. In the long run, the cost of every bit of railway improvement must be paid for by those who buy tickets and ship freight. Economy in the administration of our railways is just as important in the interest of the general public as if the railways were actually under government ownership.

That is sound doctrine, forcefully expressed. If the public forces the railways to enormous outlays on uneconomical electrification schemes,

it will find itself compelled to pay the interest on the swollen capital in the shape of increased fares and freights.

We say no word against the change from steam to electricity when and where investigation by competent experts prove that such a change is justifiable. What we do urge is that such expert study should be given to every such change and that unbiased expert opinion should be heeded by those who exercise control over railway operations on behalf of the public.

There has been much said of late concerning the duty of engineers toward the public. It seems to us that this is one of the cases where engineers may wisely exert their influence so far as possible in support of the principle above laid down. The tendency so frequently observed to force the expenditure of great sums either from public treasuries or by public service companies in directions which are not supported by sound engineering principles—this tendency is one which engineers may well unite to oppose.

It need hardly be here said that this is the keynote to success in all private business, small or great, and it is even more essential in the conduct of public business—the carrying on of Government under the complex conditions of the present day.

It is expert study of each problem by itself that we urge, therefore, in this matter of electrification, and it is not amiss to add that a heavy responsibility is upon the engineer to make his study of such problems complete and unbiased.

LETTERS TO THE EDITOR.

Esperanto for International Congresses.

Sir: Under "Editorial Correspondence" in your issue of Aug. 4, is an article headed "Some Impressions of The International Railway Congress." Almost the whole of this article is a wail, lamenting the fact that almost all the papers were in French or German and that many of the American delegates were unable to understand them. Complaint was also made of the fact that discussion was almost impossible, as all remarks had to be translated into three languages before they could be understood. In marked contrast to this was the report of the Sixth Esperantist Convention in Washington, where 1,000 delegates from many countries, representing 30 different languages met and discussed all sorts of subjects with perfect ease and comprehension.

Many international societies have their discussions and in Esperanto. The crying necessity for such a simple means of communication is apparent. Esperanto is a natural, extremely easy and practical language destined for just such purposes as international congresses, journals, etc. Any educated man can read it at sight and can write it in a week. I myself correspond with men in my profession in all the countries of Europe without inconvenience.

I enclose a copy of La Internacia Scienca Revuo and ask a little of your space for my letter.

Ellwood Wilson,
Superintendent Forestry Division.

Grand Mére, P. Q., Sept. 14, 1910.

Salaries to Instructors in Engineering Schools.

Sir: With no desire to reopen the discussion which a short time ago occupied some space in the pages of Engineering News regarding the advantages of a college course for students of civil engineering, attention is called to three advertisements in "Situations Open" columns of Engineering News of Aug. 18, 1910, which, in my opinion, bear upon the subject.

The clippings referred to are advertisements of technical schools for instructors in civil engineering and the point to which attention is directed is the value placed by the advertisers upon such service. An instructor in civil engineering is wanted. He must be an experienced man; he must be competent to practice his profession; he must be one who *has* practiced it; he must be willing to retire from his practice and devote his time to teaching for the yearly sum of $1,200, or for $1,000, or, perhaps, for $800.

Here is the value placed by the college itself upon the services of its graduates.

In all candor what kind of instruction is given by an institution which expects to secure for $800 per year the services of a man competent to teach civil engineering and what kind of a "Professor" of civil engineering can be had at that price? Respectfully,

W. N. Collier.

La Crosse, Wis., Aug. 23, 1910.

[The condition that Mr. Collier remarks upon is not at all peculiar to the schools of engineering; it is prevalent throughout the whole field of education. How to provide proper compensation for the instructing staff is one of the most troublesome problems of college administration. Aside from that, it should be remembered that the positions advertised for here are in the lowest grade of the faculty and do not indicate the salaries which the "full professor" in an engineering school may expect. Even for these "instructors," the opportunity for outside work, both during the school year and in the four months' vacation, may add materially to the annual income. And, finally, it must be recognized that to some men there is a certain attractiveness in teaching which leads them to accept professional positions at a much lower salary than they could command in other work. The amount they are paid is no exact criterion of their worth.—Ed.]

More Western Ideas on Conservation.

Sir: I have just read a communication appearing on page 155 of Engineering News, of Aug. 11, 1910, submitted by Mr. Geo. M. Bacon, M. Am. Soc. C. E. He still leaves three or four matters relating to "conservation" in a very unsatisfactory condition, in so far as definitions are concerned. Who is to define "conservation" so that all who so wildly preach it now will know what it means?

The point which I hoped to make relative to a national tax on our undeveloped resources being unjust was this: The country has developed from the Atlantic to the 100th meridian, speaking in general terms, and all resources found there have gone into the hands of the people. It is more difficult to develop the resources of the remaining states. Yet the people who are to settle there are not only to undergo the hardships of the pioneer, but the remainder of the country (the national government) is to obtain revenue from the resources that are to be used. Why is this? Is the citizenship of Wyoming and Utah less worthy than is that of Kansas and Missouri?

The Mississippi Valley once belonged to the general government. It was not used for speculation by the government. It was held to be a great opportunity for home builders. It is a country of homes to-day. Utah and Wyoming should demand similar treatment. These newer States should be accorded the same advantages and opportunities for growth that prevailed when the Mississippi Valley was settled. Maine did not profit through the settlement of the lands of Kansas or Iowa, Neither did Wyoming. Why should both Maine and Kansas now profit through the development of the resources of Wyoming?

The navigable streams of the Eastern States belong to the nation at large. Why should the commerce on these streams not be taxed? The theory that the extreme "conservationists" bring to us, when applied generally, would demand this. The national government has never held natural resources for revenue or profit. It has taken the wise course which means that resources are for the use of the people.

This talk about monopoly in the use and control of resources has but little of truth in it. As between local and national control, monopoly can develop much better under the latter. Our great monopolies have grown up largely under the protection of federal statutes. If Mr. Bacon can tell me why, at this time in the history of the country, the Eastern citizen of the United States should feel that he has any special interest or ownership in Western resources, it would assist me to understand some of the phases of the "conservation" movement that are not plain now. The West has always been a place where the sons of the East have been able to go and establish themselves. It should always be considered as such until the last remaining resource has been developed. The nation should afford some opportunities for those who have the ambition and the courage to undertake development. The nation should not look upon natural resources as a basis for revenue. It would seem that the sordid, financial views of the present generation had even pervaded the minds of those who have brought forth the "conservation" movement.

I have always held that the resources of Western States cannot be wisely administered from Washington. My convictions have not been established by adding one theory to another. I spent five years in government service and was in Washington for a number of months each year during that period. I discovered while there how many government bureaus there are that are of no value to the public. These departments secure their support by the political favors they are able to return and by the most complete system of advertising that has ever been devised by man.

When I say that the "conservation" movement was started for the benefit of bureaus, my judgment is based on what I already know of these departments. If any person wishes to study the subject, let him take up the Forest Service. Its [former] chief has been one of the most capable politicians that the nation has thus far seen. I have attended western gatherings of various kinds for the last twelve or fifteen years, and it has been the invariable rule to find Mr. Pinchot at each one. He has, with other bureau chiefs and the agents of railroads and other large corporations, been able to organize things prior to the appearance of delegates, so that he will get all that he desires. Through his own press bureau he has been able to repay those who have cooperated with him in other ways. When I know all this by personal contact with Mr. Pinchot and his agents and when I have studied his press bureau system to some extent on the ground at Washington, and when I is responsible for the "conservation" movement, does not seem to me that it requires any special mental ability to say that "conservation" is a part of the old publicity work, and that it is for the protection of the bureaus. These departments must die a natural death when the remaining public resources have gone into the hands of those who can use them. The sooner the transition begin the better for all concerned. I am confident that three-fourths of these departments could be obliterated to-day and the general public would never know it in so far as the work now performed is of any value to the people.

I cannot see how the national government can prevent people from investing in engineering works, such as Mr. Bacon describes. It is impossible for some office at Washington to have detailed surveys of every dam site in the country. Investors can always protect themselves by securing the services of a competent engineer, such as Mr. Bacon. I do not grasp the point Mr. Bacon tries to make when he says that "a little official interference would have saved thousands of dollars, which have been worse than thrown away." If any officer is responsible for an investment in dam construction such as he describes, I would say that the State Engineer or some local authority would be held accountable rather than some department twenty-five hundred miles away. It is possible that Utah has not gone as far at is should in the protection of water users. It is possible that if a little more discretion were given to the state engineer, for instance, in these matters that the need of some national supervision would not be felt. It is much easier for those who can afford it to go to Washington for favors than it might be should all these questions come to a local official who understands the situation on the ground and who knows the merits of rights which might conflict. Too often but one phase of a controversy is presented at Washington.

My position is this: The national government has never done a great deal towards protecting investors. Wall Street is an example. There is enough inferior stock on the market to-day to wreck the country. The companies that have this stock for sale are doing an interstate business. The national government does not warn investors as to the merits of the various companies. It is more difficult to ascertain the merits of the investment under these circumstances than it would be should the company plan some engineering work, such as the building of a dam or a canal system for irrigation. An engineer, such as Mr. Bacon, could always advise investors in matters of this kind. If investors proceed without such advice, they are certainly taking a risk which should be borne under their own responsibility. If failures have been made by companies investing in power and irrigation works, it will be found that they failed to get good engineering advice. I cannot think of a case where the government ever warned investors in matters of this kind.

All the trouble that we have had with the bureaus at Washington relates to the desire of these bureaus to place an unwarranted taxation burden on development, to retard one kind of development to protect some imagined wealth in another direction, etc. I have been in Washington as often as any western engineer, I presume, and I have never heard any good engineering advice come from these bureaus to prospective investors This is because these bureaus do not and cannot have such information as would enable them to give good advice.

As an example of bureau rule I should like to have Mr. Bacon study the work of the Forest Service in his own State. It would be interesting to learn how much the people of Utah have paid in grazing fees to the national treasury. Their condition should be compared with the pioneers of the Mississippi Valley. Is this money collected because the national government needs it, or is it because the Forest Service wishes to refer to this revenue when it goes before Congress to get larger appropriations to be used for all kinds of purposes, including the officially conducted press bureau? It would be interesting to learn how the grazing areas are established between the various stockmen. After this system of national control has been studied thoroughly, I should like to know whether or not the people of Utah are worthy of anything better or do they need a national supervision which is supported by a direct tax on the people of the State? Utah pays a national tax which goes to make the Hudson River navi-

ible. Utah also assents to a tax which compels her citizens to remit to the national treasury for grazing privileges, when all older States developed under a different system. The public land of the country has always been regarded as common and it has always been used by the people on the "borders" until these areas are needed for home builders. It may be wise to charge for grazing privileges. If so, there is no reason why the money received should not all revert to the states for improvements of various kinds. The states are sovereign and must defray the cost of maintaining law and order throughout the areas set aside as national forests. The United States as a proprietor should hold the lands for the benefit of the people most concerned, the people who can use the lands and who are taxed locally to support local laws.

Sincerely yours,

Clarence Johnston.

Cheyenne, Wyo., Aug. 15, 1910. State Engineer.

[We give Mr. Johnston credit for an honest belief that substitution of state for federal ownership and administrative control of the remaining public lands would be for the best good of the nation, but we are not yet ready to accept that doctrine. Moreover, we cannot but feel that, quite unintentionally, Mr. Johnston takes a sectional rather than a national view of the question at issue. We believe that the public domain is a national heritage and that a considerable portion of what is still in the possession of the people at large should be ever held for their benefit; just as some of the state lands should be held for the benefit of each commonwealth, instead of being turned over to the towns. In like manner (but put in reverse order) just as the State of Wyoming has deemed it for the public good to exercise administrative control over what some may regard as purely local matters, so has the federal government found it necessary to do the same thing in relation to the several states. Nor is this all. When Mr. Johnston rails against federal bureaucracy he exposes himself and his fellow state officers to identical complaints from the officials of the minor civil divisions of his state. Finally, since Mr. Johnston renews and makes more pointed his attack on Mr. Pinchot with each letter we feel compelled to give public expression to the opinion that in so doing he weakens his own case, however honest he may be in his attitude.—Ed.]

The Nomenclature of Bituminous-Bound Broken-Stone Roads.

Sir: As is well known by engineers and others engaged or interested in road building, considerable confusion has existed and still exists in the use of the various terms employed in connection with road building with bituminous binders.

At the convention of the Organization of City Officials for Standardizing Paving Specifications, held in Chicago, Ill., Feb. 21-24, 1910, the committee on asphaltic and bituminous pavements, through its discussions and reports, implied its sanction of certain terms. These terms, with their definitions, are, in effect, as follows: Roads built by laying broken stone, either with or without the addition of sand or gravel, and then applying a bituminous binder by the penetration method or some modification thereof are designated as bituminous macadam roads. Roads constructed by the mixing method, i. e., by mixing the metaling and the binder before placing them on the roadway, are called bituminous concrete roads.

In June, several months after the convention referred to, one of the engineering journals printed an editorial on the subject in which it stated that there had been "a partial adoption of two terms," and then gave the terms and definitions substantially as above.

On June 17, Clifford Richardson, of the Barber Asphalt Co., wrote a letter to the editor of the journal referred to, criticizing the definitions on the grounds that the term bituminous macadam, should be confined to roadways in which stones of one size are used, and that the name bituminous concrete should be applied only to a substance consisting of a graded mineral aggregate, the voids of which are filled with sand and filler.

Early in August the same journal published a letter from George C. Warren, of the Warren Bros. Co., in which the use of the terms bituminous macadam and bituminous concrete was discussed at considerable length. Mr. Warren holds that no material should be called bituminous concrete unless it is made up of a mineral aggregate in which the interstices of the coarser particles are filled with smaller particles.

In regard to bituminous macadam, he states that the term was coined by the late Frederick J. Warren to describe a certain pavement laid by a patented process, and claims that the term is a misnomer, since the pavement is not macadam but is what should properly be called bituminous concrete. Because of the conflict with an established trade name and its alleged misapplication, Mr. Warren urges its abandonment and, on behalf of the Warren Bros. Co., announces that the company will give up the use of the name if leading writers and engineers will do likewise.

In a later letter, Mr. Warren lists a large number of terms and proposes definitions for them. He again suggests that the expression bituminous macadam be abandoned, putting forth as arguments in support of such a course the fact that the term has been misused in the past and the claim that it "does not clearly define any specific form of construction in general use."

It is a fact that the term macadam, as applied to the modern broken-stone road, is a misnomer, for the stone roads of the present bear but little resemblance to those built by McAdam. Yet the name has been sanctioned by many years' use and the addition of a bituminous binder to a road universally known as a macadam road would seem to furnish no reason for abandoning the use of the word macadam to describe it. Since the road was a macadam road before treatment and the binder applied is a bituminous material, why should the name bituminous macadam not properly apply?

As roads built of a mineral aggregate and a bituminous binder are naturally divided into two classes in accordance with the manner in which they are built, it is logical to assign to either of the two a name suggestive of the method used in its construction. For this reason the term bituminous concrete seems particularly fitting for the description of a bitumen-bound broken-stone road built by the mixing method. The manner in which the materials are prepared is obviously analogous to the mixing of concrete and, furthermore, the materials themselves and their functions in the mixture are similar in both cases.

It is difficult to see merit in the contention of Mr. Richardson that the term bituminous macadam should be confined to roads in which stones of only one size are used. Although the roads built by McAdam were so constructed, it should be borne in mind that the macadam road of to-day is not built in that manner, nor is it the modern form of McAdam's road. It is, rather, a modification of the construction employed by Tresauget, although it has been named for McAdam.

The terms bituminous macadam and bituminous concrete, employed as herein proposed, are not misnomers. Moreover, they have whatever standing may be conferred by usage and no valid reason for discarding either of them has yet been suggested. Their use need not interfere with the adoption of other terms required for the more specific designation of the varied forms of bitumen-bound roads, nor does it conflict with the terms now current.

Road building is fast becoming an important branch of engineering and the need for a comprehensive and exact system of nomenclature becomes more and more urgent as the number and complexity of methods increase and new materials are added to those previously in use. A discussion of this subject in the columns of Engineering News, either editorially or by the readers of the journal would be welcome.

T. A. Hulbert.

557 West 124th St., New York City, Sept. 13, 1910.

[In attempting to agree on a nomenclature for modern road construction, it would be well to remember that, broadly speaking, macadam served to denote body material, binder, and method of construction for over half a century, or until tar was substituted for dust and water as a binder. Tar macadam then came into use, both in fact and in name. The name did good service until (1) other sorts of bituminous binders and (2) variations in the method of incorporating these bituminous binders with the broken stone came into vogue.

Macadam is so firmly established in road nomenclature that it is likely to remain as the basic term for broken-stone roads, regardless of binders or construction methods. The question may thus become, what qualifying words shall be used (1) to differentiate dust-and-water-bound, tar-bound, asphalt-bound, etc., macadam, and (2) how shall different methods of incorporating the binder and the stone be distinguished? Or, instead, an attempt may be made to arrive at a terminology which has to do merely with the finished road rather than its components and fabrication.

We do not pretend to say that the subject may not be approached from some other viewpoint. The one suggested may be sufficient as a basis for discussion.

Attention may well be called to the undesirability of having road terminology dictated by any one or more proprietary materials or methods. On this phase of the subject, as well as on standardization in its broader aspects, the interested reader may profitably consult the paper on "Tar Macadam," by the City Engineer of Edinburgh, Scotland, presented elsewhere in this issue. It will be seen that the author of that paper sweeps away all proprietary processes at the very outset, as not only unnecessary, but undesirable, and discusses tar macadam as a purely technical question, best kept in the hands of engineers and chemists employed by the city or state. It will also be seen that he uses "pitch macadam" to denote those roads in which the tarry product is introduced after the stone is in place, and "tar concrete" to denote roads built of tar and stone mixed before those materials are placed. It should be noted, however, that the author in question is not discussing uniform terminology, but rather standardization of materials and methods.—Ed.]

Notes and Queries.

E. E. R., Coatesville, Pa., asks for bending moment formulas applicable to plain steel floor-plates supported on two opposite edges only. The bending effect of concentrated loads is the point at issue. For uniform load, of course, the simple beam formula applies, i. e., ⅛ load per sq. ft. × span ft.^{2} = 1/6 allowed stress × thickness ins.^{2} In his case, span 6 ft. c. to c., thickness 5/16 in., the plates resting on the top flanges of I-beams 6 ft. apart to form a charging floor, we may assume a stress of 12,000 lbs. per sq. in., which gives

$$\frac{1}{8} w 36 = \frac{1}{6} 12000 \times \left(\frac{5}{16}\right)^2$$

or w = 43 lbs. per sq. ft.

This calculation is independent of the width of the plate. Concentrated loads, however, will distribute more effectively on a wide plate than on a narrow one. In the present case, the plates being say 4 ft. wide, how great a concentrated load may be placed on the floor, if the load occupies an area of 12 ins. square?

An obvious approximate way of dealing with the problem is to assume that if the width is not too great the weight distributes uniformly across the width, giving $\frac{W}{4}$ as the load on a 12-in. width. Disregarding the 12-in. length of loading, the maximum load at midspan would be (from $\frac{1}{4} Pl = SI/c$), $P = \frac{1}{4} W = 130$ lbs., or $W = 520$ lbs. The strip in the middle of the width would certainly be overstressed, but if the elastic limit were reached the adjacent strips would take a larger share of the load and no danger would result. This method is too crude, however, to be really satisfactory. Suggestions for more accurate methods will be useful.

THE BY-PRODUCT GAS-WORKS PLANT of the Citizens' Gas Co., at Indianapolis, Ind., has shown good results according to the company's semi-annual report. There are 50 by-product ovens, and operation was begun in November, 1909; part of the time only 25 ovens were in use, and when all were in use (for four months) they were operated on the slowest possible schedule. This was due to the undeveloped state of the company's business and incomplete facilities for handling coke. The plant is designed for charging 60 ovens per day, but during the four months only 36 were charged daily. Even on this slow schedule the gas production was 50,000,000 cu. ft. in excess of the demand. The business is developing and the distribution system is being extended. For the gas actually distributed and sold, it is found that the cost of distribution and management (not including taxes and insurance) was 13.1 cts. per 1,000 cu. ft. The accompanying figures show the expenditures and receipts per ton of coal carbonized (1) as actually occurring for the first six months of operation, using 260 tons per day, and (2) as estimated for regular working as 375 tons per day:

	Actual results.	Estimated.
Coal per day	260 tons	375 tons
Expenditures per ton:		
Cost of coal	$2.494	$2.750
Labor, supplies and repairs	.334	.686
Distrib. and management	.349	.736
Taxes and insurance	.009	.149
Total	$3.276	$4.321
Receipts per ton:		
Coke	$2.336	$2.450
Ammonia	.447	.405
Tar	.242	.180
Gas	1.543	2.280
Total	$4.568	$5.315

Annual Convention of the Roadmasters and Maintenance of Way Association.

The twenty-eighth annual convention was held at the Great Northern Hotel, Chicago, on Sept. 13 to 16. The chair was taken by the President, Mr. James Sweeney (Chic. & E. Ill. Ry.). The attendance was fair, but the reports and discussions were rather weak and disappointing. The society has now about 400 members. Brief addresses were delivered by Mr. F. O. Melcher, Vice-President of the C., N. I. & P. Ry., and by Mr. J. B. Berry, Chief Engineer of that road. The election of officers resulted as follows: President, T. Thompson (A., T. & S. F. Ry.), Joliet, Ill.; Secretary, W. E. Emery, Chief Engineer of the Peoria & Pekin Union Ry., Peoria, Ill. The next meeting will be at St. Louis, Mo., in 1911.

CARE OF TRACK MATERIAL AND TOOLS.—One report discussed methods of piling and storing ties, rails and other material at points along the line. Reference to the piling of fence and crossing planks was struck out, at the suggestion of Mr. C. Jones (C. B. & Q. Ry.). The reason for this was that such material should not be (and rarely is) plied along the track, but is kept at storeyards and only sent out on requisition. The report was changed in this respect to read that "crossing plank and fence lumber should not be ordered until needed, and should be used within 30 days after it is received."

There was some discussion as to the recommendation that in good track one spare rail for each two miles is sufficient. Mr. Jones (C. B. & Q. Ry.) thought there should be one spare rail on each mile; his road has recently changed from this to the method recommended, but he has protested against it. Mr. Sweeney (C. & E. Ill. Ry.) remarked that on a railway of considerable length there would be a material increase in the amount of money tied up if a spare rail was used on each mile instead of each two miles. One member stated that he kept no spare rails on the track, but keeps a small stock at the division yard. Broken rails are spliced in the track until a new rail is sent from the yard.

Another feature of the report was in regard to getting more use out of the track tools. It often happens that one section has some surplus tools that are not in use, while another is sending in requisitions to the roadmaster or engineer of maintenance for additional tools. The plan was to provide for an interchange between the sections. Some of the members opposed this as being troublesome and unnecessary, but the general opinion was that the plan was good and in the line of economy. The arrangement proposed by the report was as follows:

> For ordinary repair work, the foreman should make his requisition on the roadmaster for tools and material every 30 days. He should be furnished with a material blank on which he should enter all tools on his section which will not be used for the next 30 days. This blank should be pinned to his monthly requisition. This will enable the roadmaster to transfer tools and material from one section to another and thereby avoid making requisition for supplies which he has on his division available for use. A great deal of money can be saved by a system of this kind.

SWITCH TARGETS.—This report related to a standard design of targets. Of six members of the committee, four advocated a single target (showing when the switch is set for the siding or turnout); one advocated a double target, and one advocated a semaphore arm in place of a target. The discussion got mixed up with questions of block signals and interlocking. The principal advocate of the double target system was Mr. Clough (N. Y. Central Ry.), whose argument was that as there are two lights by night there should be two targets by day. The answer to this was that the "main track" light at night was to indicate the position of the switch for the guidance of the engineman, while by day he can see the turnout and the switchstand. As to the semaphore arm, it was pointed out that the Railway Engineering Association objected to this as being liable to cause confusion with block or interlocking signal indications.

It appears that a number of important railways have adopted the single target system, and that the preference is for a red disk of large size (14 to 18 ins. diameter). By a vote of 25 to 24, the association recommended the adoption of the single target switchstand (showing a target only when the switch is open) for all track, whether single or double track lines.

INSULATED JOINTS AND RAIL-JOINT FASTENINGS.—This reports that, as a rule, the insulated joint is the weakest joint in the track, whereas it should be stronger than the others. The rails meeting at this joint should be anchored, in order to limit expansion and contraction to a minimum. With a large expansion movement the fiber insulating sole plate or base will be worn and destroyed. A number of insulated splice joints were mentioned, and also the Mock joint, which has an outside easer or relieving rail to engage the wheel tread and carry it over the joint and the insulating end post between the rail ends. Joints of this design have given good results in three years' heavy service on the Chicago & Western Indiana Ry. It was pointed out, however, that this joint should be applied on new rail, so as to insure that the easer rail will be the exact height of the track rails. If it is higher (as when applied to worn rails) it will cause a shock to cars, and the joint may be broken. Mr. Sweeney (Chic. & E. Ill. Ry.) considered that a common defect of insulating joints as they exist in the track is too wide an expansion space. An agent of a joint manufacturer called attention to the fact that the joint should not be spiked to the tie, but that the spikes should only hold it in line.

The second part of the report recommended a base-supported joint (bridge type), so fitted that the rails cannot work vertically in the joint. Four-bolt splices, not over 26 ins. long, were recommended, with holes arranged for placing the bolt heads alternately inside and outside, holes to fit the bolts snugly, and rail holes to be large enough for expansion and contraction.

The discussion related mainly to individual experience and practice, rather than to joint design or improvement. Mr. Hansen (C. & N. W. Ry.) approved of a base plate and splice bars, but thought these should not be in three separate parts (as they are on his road). There was some general discussion as to the respective merits of nut locks (spring washers) and lock nuts.

The other reports were unimportant. A very brief report on cattle-guards simply mentioned some old and wooden devices, but suggested that steel cattle-guards are liable to injury by brine dripping from refrigerator cars. It approved of a surface guard having no sharp points, holes or movable slats (on which the animal will slip), but leaving a slot to receive the toe of the animal's hoof in such a way as to make it impossible to make a step forward while leaving the leg free to be withdrawn as the animal backs off the guard.

A still more brief report on tie-plates and rail anchors recommended tie-plates without self-attaching ribs or claws, but having a shoulder to fit the rail base. It went so far as to recommend a certan make of plate. Mr. Ketwin (Mo. Pac. Ry.) called attention to the fact that in 1906 the association recommended the self-attaching type of tie-plate, and on his motion it was voted to substitute the 1906 recommendations for those of the 1910 report. Ordinarily, this subject would have developed active discussion, but, coming at the close of a session, it was disposed of in short order. The report recommended also that rail anchors should consist of not more than two parts (one being preferable), and should not require any bolts or keys to hold them in place. This part of the report was accepted as information.

A paper on "Some Benefits of Association," by Mr. W. M. Camp (Chicago) outlined some of the work done by various railway and technical associations in the standardizing of rail sections and specifications, wheel gage, guard rail gage, etc. The rules for widening gage on curves have been developed mainly by the mechanical departments, but should more properly have been the work of the track or engineering department. For the recent tendency to break away from the Am. Soc. C. E. rail sections and to multiply new sections he blamed the rail makers, who persistently claimed that the Am. Soc. C. E. sections (which were practically the standard of the country) were not satisfactory. The only other paper was a short one on "Treating Timber," by Mr. J. L. Single (Long Island Ry.). This related only to the use of creosoted ties (pine, hemlock and red oak) in 1890-91, and it was stated that some of these ties are still in use.

A Single-Stage Impulse Steam Turbine for Mixed Pressures.

An interesting design of impulse turbine taking steam at variable pressure has been made by the De Laval Steam Turbine Co. It will be remembered that in the De Laval single-stage type a complete expansion of steam takes place in a single nozzle; steam entering the nozzle at full pressure expands to the exhaust or condenser pressure, converting all the heat energy available between the two temperature limits into velocity energy before the steam impinges on the buckets of the rotor. In the design noted, a series of high and low-pressure nozzles have been distributed around the periphery of the rotor so that a sufficient number of nozzles of various ratios of expansion are provided to suit a great variety of conditions. Thus, one set of nozzles may receive high-pressure steam and exhaust to the condenser, and another set may receive, at the proper time, low-pressure steam and exhaust to the condenser, the latter nozzles being also available for use with high-pressure steam exhausting to the atmosphere, since this operation involves about the same ratio of expansion.

One of these turbines of 150 HP., driving two 16-in. centrifugal pumps, has been installed in a large steel mill to receive the exhaust from a number of hydraulic pressure pumps and other auxiliary machines, all exhausting into a common header. Because of the possibility of here using live steam in a separate set of nozzles to supplement any deficiency in power from the exhaust steam, it was not considered necessary to install a regenerator for storing the variable heat of the exhaust, nor was a reducing valve fitted to supply steam at low pressure to the exhaust header. The turbine exhausts into a large central condensing plant, which also serves a number of rolling-mill engines and in which the vacuum varies from 18 to 27 ins. having an average of about 22 ins. There is a possibility of losing this vacuum entirely at times, due to air leaks or engine troubles. This turbine is designed to carry full load when using steam at about atmospheric pressure when receiving steam at 120 lbs. gage, or at 90 lbs., always exhausting into a vacuum of 22 ins. In an emergency it will operate non-condensing with steam down to 90 lbs pressure. All these changes are carried out automatically by the turbine itself, with the exception of the shift from condensing to non-condensing operation. To secure such automatic operation, the turbine is fitted with two governor-operated steam valves and two governors, one for the high-pressure line and one for the low-pressure. The high-pressure line governor is set to open its valve at a few revolutions below normal turbine speed; above this speed the high-pressure supply is tightly closed. The low-pressure line governor is set to cut down the low-pressure supply above normal speed. On the failure of the low-pressure supply of steam, as the machine drops a few revolutions in speed (less than 2%), live steam is admitted to the high-pressure nozzles. At the same time, the low-pressure nozzles may continue to utilize any exhaust steam which may come to them. The pressure limits of this exhaust have been found to vary in practice from 2 lbs. above atmosphere to 5 ins. of vacuum. An emergency stop consisting of a butterfly valve in the turbine exhaust connection, is provided to guard against runaways, such as might occur in case the high-pressure valve should leak when the turbine was lightly loaded. This valve is normally held open by a spring but is closed by a piston working in a cylinder to which com-

THE ACCIDENT ON THE "NORTH DAKOTA," which was noted in our issue of Sept. 15, has been investigated by a board of three naval officers. According to the report of this board, the accident was due to "the erroneous principle and design of the installation of the system of burning fuel oil." The explosion was caused through the ignition of leaking oil.

A DERAILMENT AT HIGH SPEED Sept. 12 wrecked a passenger train on the Hocking Valley Ry. two miles north of Lemoyne, Ohio. The locomotive left the rails first and rolled over on its back, wheels upward. The cars left the rails and many were overturned. The accident is ascribed to defective ties. According to press reports, a new model locomotive was being tested on this train. Mr. G. J. De Vilbiss, Superintendent of Motive Power of the Hocking Valley, and Mr. L. C. Engler, Road Foreman of Engines, were in the cab and were killed together with the engineer. About a dozen passengers were injured.

A BUTTING COLLISION between two passenger trains on the Chicago, Burlington & Quincy R. R., Sept. 16, one mile north of Holt, Mo., killed one man and injured 19 others. The accident is ascribed to a misunderstanding of train orders.

A butting collision between two freight trains seven miles north of Cairo, Ill., Sept. 18, on the Mobile & Ohio R. R., killed four men and injured two others. This collision is ascribed to failure to transmit train orders on the part of the operator at Beechridge, Ill., who is alleged to have been intoxicated.

Two trolley cars at Union City, Ind., collided head-on Sept. 17, killing one motorman and a passenger and injuring 13 other persons.

AUTOMATIC CROSSING ALARMS comprising a semaphore and a bell are required at grade crossings in Los Angeles, Cal., under a recent city order.

A REMARKABLE RAILWAY ACCIDENT is recorded in a recent issue of the St. Louis "Globe Democrat" as follows:

Arcola, Ill.—September 12.—A runaway horse dashed into a Vandalia freight train running 30 mi. per hr. on the Terre Haute and Peoria division, near Arcola, this morning, and caused a $10,000 wreck. The car which the horse struck was thrown from the track and ten other cars were piled up.

This would seem to make amends for some of the numerous grade crossing accidents in which it is the horse that gets the worst of it.

A FLYWHEEL EXPLOSION at Whippany, N. J., Sept. 16, wrecked the Hanover mill. The engine had been shut down and was without a governor. A laborer started the engine, on his own responsibility, with the result that it ran away. The laborer did likewise, reaching a safe distance before the wheel burst.

A RECEIVER EXPLODED at the Boylston St. powerhouse of the Boston Elevated Ry. Co. at Cambridge, Mass., Sept. 16. One man, an assistant engineer, was seriously hurt. According to press reports, the receiver which exploded was that of a 2,700-KW. compound engine-generator unit.

A ZEPPELIN DIRIGIBLE balloon, the sixth and latest of this type, was wrecked at Baden Baden, Germany, on Sept. 14. It is reported that through the carelessness of workmen while the airship was being run into its hanger, a benzine tank in the rear gondola exploded setting fire to a gas compartment which in turn exploded and caused the explosion of several others. It is reported that this dirigible had ascended previously that morning with 12 passengers for a commercial trip, but after covering about 20 miles was obliged to return because of motor troubles. This craft was under charter of the Passenger Airship Co., having replaced in passenger service the recently wrecked "Deutschland." During the past 18 days she has made 34 commercial trips covering 2,000 miles and carrying something more than 300 passengers. It is also reported that passenger service will be again resumed in a few weeks with the new "Deutschland," a dirigible of this same type which is nearing completion.

THE "MAURETANIA," giant Cunard transatlantic liner, made a passage from Daunt's Rock to Sandy Hook, ending Sept. 16, in 4 days, 10 hrs., 41 min., which is ten minutes less than the world's record across the "short course" of 2,780 nautical miles—a record held by the "Mauretania."

MORE BRIDGE DYNAMITING.—Two cases of bridge dynamiting occurred in Peoria, Ill., recently. A shipment of steelwork was blown up while on the cars in the railway yards, destined for a bridge being built near Peoria. The same night an explosion was set off at the plant of the Lucas Bridge & Iron Co., destroying part of their shops.

LOW WATER CAUSING SLIDING BANKS is reported to have given trouble along the Red River in North Dakota. Local accounts say that bridge piers have been shifted by the slipping ground.

GAS AND ELECTRICITY METERS in New York City, tested on complaint by the Public Service Commission in August numbered 207. Of the 179 gas meters tested on complaint 30% were 2% or more fast and 14% were 2% or more slow. Of the 28 electricity meters all were within legal limits (4% slow or fast) except one which was slow. In addition 4,694 new and 23,394 repaired gas meters were tested.

INSTRUCTION IN MUNICIPAL AFFAIRS at the leading colleges in New Jersey has been requested by the New Jersey State Civic Federation in letters sent to Princeton University, Rutgers College and Stevens Institute. The requests read as follows:

The records of the various city governments, as disclosed in public print in the last three years, have been such as to call serious attention to the inadequacy of present methods of administering public funds and recording the same in a straightforward accounting to the people.

Realizing that the only remedy lies in an educated and expert management and control of municipal affairs, the New Jersey State Civic Federation, through its proper committee, calls upon your honorable body to establish such a course in your curriculum as shall prepare young men for an intellectual grasp of the powers and duties of the administrative side of a municipality, and fitting them to assume, as experts, the matters of accounting in city affairs.

THE DENVER WATER BOND ELECTION of Sept. 6 resulted in a vote of 7,032 to 2,334 in favor of the issuance of $8,000,000 of bonds for the construction of a municipal water plant. The issuance of the bonds has been made at least temporarily impossible by a decision in the United States District Court just before the election. Presumably, this decision accounts for the small vote out of a total registration of 38,495, but it did not prevent the large majority just stated. The court appears to have sustained, at least tentatively, the contention of the water company interests to the effect that the charter amendment of May, 1910, taking away from the City Council all control over water matters and placing sole control in the Public Utilities Commission, and at the same time providing for the possible issue of bonds for the construction of a competing municipal plant was void, in view of a contract of 1890 between the city and the water company and subsequent municipal legislation based upon that contract. The court appears also to have held that the company is at least entitled to the benefit of the doubt as to whether or not the city is not bound either to buy out the company at the valuation fixed a few years ago by a board of engineering appraisers, or else grant the company a new franchise. The city has carried the case to the United States Court of Appeals, which will convene at St. Louis in December.

ENGINEERING EXHIBITS AT THE NEW YORK State Fair, Syracuse, N. Y., during the week Sept. 12-17, were made by a number of state departments. The State Department of Health showed a model of a sewage disposal plant in operation (with water). The model included a grit chamber, septic tank, sand filter beds, contact beds, sprinkling filter, final settling and disinfection tank and a sludge bed.

The State Engineer and Surveyor exhibited a bird's-eye view of the entire barge canal in colors, drawn to such a scale as to occupy a space of about 6 × 21 ft.; also models of barge canal locks and various photographs showing the canal under construction. In addition to this, there was a continuous stereopticon exhibition of barge canal views.

The State Water Supply Commission showed a large collection of photographs of notable waterfalls and various maps and diagrams illustrating stream flow and rainfall. A map 6 ft. sq. showed the location of existing and proposed power developments and storage reservoirs throughout the state, together with all streams, the principal highways and railroads and the Adirondack Park and Forest Preserve. Besides the pictorial exhibits, the State Water Supply Commission showed a number of models of various installations of actual apparatus related to this work. These included a current meter, stream-gaging station, an electrical power transmission line, an irrigated farm with a reservoir supplied with water by means of hydraulic ram, a Pelton impulse water-wheel in operation, and an electric generator operated by a water-wheel, etc.

Non-confirmed reports state that the Forest, Fish and Game Commission had an exhibit which included a small plantation of forest seedlings.

TURBINES FOR A VERY HIGH HEAD are in course of erection in the hydro-electric power plant of the Michoacan Power Co. at Noriega, Mexico. According to a general description published in the "American Machinist" of Aug. 18, 1910, these turbines, which are being built by the I. P. Morris Co., of Philadelphia, Pa., are of the inward-flow Francis type with horizontal shaft and volute casing. Each of the two units is designed to deliver 6,000 HP. at a speed of 514 r. p. m.

The high head, 670 ft., combined with the necessity of a penstock 5,600 ft. long, introduced more than the usual amount of difficulty of taking care of the water-hammer effect when the turbine gates are closed and at the same time securing a satisfactory regulation. A 20,000-lb. flywheel, mounted on the generator shaft between the turbine and the generator rotor was found necessary to supplement the flywheel effect of the rotating parts of the combined turbine-generator unit. An elaborate system of relief valves is expected to prevent dangerous rise of pressure in the turbine casing.

The Noriega turbines are a step in advance, in the matter of height of head, of the 18,000-HP. turbines in the plant of the Great Western Power Co., near Oroville, Cal. The Great Western turbines designed for a head of 525 ft., which were briefly described in Engineering News, Feb. 24, 1910, p. 233, have been in continuous operation for about one year under a head of 420 ft. without showing signs of erosion.

THE ST. LOUIS MUNICIPAL BRIDGE is progressing, and we have the following particulars as to the present state of the work from Brenneke & Fay, of St. Louis, who are the Resident Engineers. The Consulting Engineers are Boller & Hodge, of New York. Pier No. 1 (on the St. Louis side) has been landed on rock, the caisson sealed, and the masonry completed nearly to the bridge seat. Pier No. 2 has the caisson framed and ready for launching. Pier No. 3 has the caisson sinking in progress and on Sept. 17 it was within 3 ft. of bed rock. Pier No. 4 (on the Illinois side) has been landed on rock, the caisson sealed and ten courses of masonry laid. For the superstructure, the mills have rolled 90% of the material; the bridge shop has the drawings completed, 30% of the templets completed and 15% of the material fabricated. The bridge will have three main through-truss spans of 668 ft., the trusses being 110 ft. deep at the center. The lower deck will carry railway tracks; an upper deck will carry a roadway, with sidewalks outside of the trusses. The Missouri Valley Bridge & Iron Co., of Leavenworth, Kan., has the contract for the substructure. The American Bridge Co., of New York, has the contract for the superstructure. No work for the approaches is under contract.

TESTS OF THE EFFECT OF SEAWATER ON CONcrete are to be made at the Panama Canal, according to the following note in the "Canal Record":

Experiments will be undertaken by the Atlantic and Pacific Divisions to determine the effect of sea water on the concrete for the lower locks at Gatun and Miraflores, in order, that it may be decided whether it will be advisable to take steps for protecting the concrete. To this end the division engineer of each division has been directed to have made six slabs about three feet square and not less than six inches thick of concrete, the same as that used in the lock masonry, the larger parts of the aggregate to be forked away from one face of the block leaving that face with a finish similar to that of the lock walls. Two of these slabs will be left untreated; two of them will be treated with sodium silicate in the form of soluble glass in solutions of different strength, and two of them will be treated by Sylvester's process with alum and soap, using ¾-lb. of soap to one gallon of water applied boiling hot for the first wash, and 24 hours later, a solution of alum, 2 oz. to the gallon, applied cold. One of each pair of slabs will be given a double coat, and the other, two double coats of the respective washes. After they have been treated in this way the slabs, together with those left untreated, will be exposed to the action of salt water at a point as near as possible to the location of the lower guide walls at Gatun and Miraflores. They will be placed in the water simultaneously and allowed to remain immersed until the walls are erected, and it becomes necessary to decide whether or not they are to be treated to resist salt water.

The walls that will be subject to action by salt water will be only those of the lower or sea level locks, and the guide walls leading into these locks. At Miraflores, about 1,400,000 sq. ft. of surface will be thus exposed, and at Gatun about 1,270,000 sq. ft.

CEMENT PRODUCTION IN 1909.—More cement was made and used in the United States in 1909 than in any preceding year and the price per barrel was lower than ever before. The production in 1908 was 52,910,925 bbls., valued at $44,477,653; the production in 1909 was 64,196,386 bbls., valued at $51,232,979.

The increase was mainly in the output of Portland cement—62,508,461 bbls., valued at $50,510,385, as against 51,072,612 bbls. in 1908, valued at $43,547,679. The output of natural and puzzolan cement formed only a small percentage of the total cement production.

The average price of Portland cement [at the mill] per bbl. in 1909 was less than 81 cts.; the average price per bbl. in 1908 was 85 cts. Portland cement cost $3 a bbl. in 1880, but by reason of improvements in method of manufacture it can now be profitably sold for 80 cts. a bbl.

In 1909 there were 103 Portland cement plants in operation, an increase of 5 over the number working in 1908. Of these plants 21 were in Pennsylvania, 12 in Michigan, 10 in Kansas, 8 in Ohio, 7 in New York, 6 in Indiana, 5 in Illinois and 5 in California.

Most of this cement was used at home, for the United States has only a small export trade in cement, consuming from 1 to 3% of the production. This country's immense natural resources of cement-making materials and its many well-equipped cement plants, however, should make it a strong competitor for the outside world's cement trade.—Advance bulletin of the U. S. Geological Survey.

A WATER-TUBE LOCOMOTIVE BOILER is the feature of a high-speed passenger locomotive exhibited at the Brussels Exhibition (Belgium) by the Northern Ry. of France. In 1904, the late Mr. DuBousquet, Chief Mechanical Engineer, decided to equip a locomotive with a water-tube boiler of the DuTemple type, as used in the French navy. This engine was put in service in 1907, but the firebox gave considerable trouble. To prevent trouble from scaling, a marine type of blow-off was fitted, but they were not liked by the men and were rarely used. In spite of this, however, there was very little scaling of the tubes. In 1909, a new firebox was fitted, designed by the Creusot Steel Works according to the suggestions of Mr. DuBousquet. This has a central upper steam drum and two lower side drums. These are connected by several rows of small tubes, the outer ones inclined and the inner ones of approximately horseshoe shape. Near the forward part of the firebox, however, the inner tubes form a semicircular arch, the tubes then rising vertically to the steam drum. Between the firebox proper and the tube sheet is a combustion chamber, also formed of tubes. A steel cover is fitted over the tubes and covered with the usual jacketing. An article in the "Railway Engineer" (London) from which our information is taken states that the engine has run 20,460 miles, and that after 6,200 miles the tubes showed no signs of incrustation. In service the engine takes a train load of 270 tons up a long grade of 0.5% at 65 m. p. h.

The engine is a four-cylinder compound of the 4-4-4 class, a four-wheel truck being placed under the firebox on account of its length and weight. The principal dimensions are as follows:

Driving wheels (4)	6.7 ft.
Weight in working order	77.2 tons
Cylinders, h. p. (2)	13.6 × 25.6 ins.
Cylinders, l. p. (2)	22.4 × 25.6 ins.
Grate	7.2 × 5.3 ft.
Height from grate to steam drum	5.3 to 4.9 ft.
Water tubes: No. 290, diam.	1.2 to 1.4 ins.
Water tubes: No. 168, diam.	1.0 to 1.4 ins.
Water tubes of combus. chamber, No. 40, diam	1.2 to 1.4 ins.
Boiler tubes; Serve ribbed; No. 136; length	14.1 ft.
Diameter outside	2.8 ins.
Boiler pressure	235 lbs.
Heating surface; firebox	1,032 sq. ft.
Heating surface, tubes	2,474 sq. ft.
Total	3,506 sq. ft.
Grate area	38 sq ft.

MUD FROM SAN FRANCISCO BAY, according to the "Engineering and Mining Journal," brings a price of 25 cts. a cu. yd. The State Harbor Commission formerly dumped the mud dredged into the deep waters of the bay at a cost of 10 cts. a cu. yd. for the complete operation. It was found that this mud, which is described as a soft, sticky, blue-black material almost like paint, was suitable for sealing oil wells, lining oil reservoirs, etc. It was originally sold at $120 per carload, but the demand exceeded the supply and the Harbor Commissioners have recently raised the price to the figure stated above.

GOVERNMENT AID FOR ROAD IMPROVEMENT in Great Britain was authorized by an act of Parliament known as "the Development and Road Improvement Funds Act of 1909." The Road Board formed under this Act has notified local authorities that in submitting applications for aid in road construction special consideration should be given to the following:

(1) Reconstruction of important roads, the condition of which is exceptionally bad and cannot be improved without reconstruction.
(2) Widening of important roads which are dangerously narrow.
(3) Surfacing with granite, basalt, or other suitable material treated with tar or other bituminous compound by some approved method main roads or important district roads which already have adequate foundations, especially those on or just beyond the outer fringe of large towns which have to carry heavy traffic without aid from the rates of the towns served by the roads.
(4) Opening out of dangerous corners and alteration of dangerous curves.
(5) Alteration, where possible at reasonable cost, of steep and dangerous gradients.
(6) Strengthening or reconstruction of weak bridges which seriously limit the use for commercial transport of roads of first-class importance.
(7) Construction of new by-pass roads to avoid villages on main roads or important district roads where the conditions are exceptionally dangerous.
(8) Acquisition in urgent cases where building is imminent of vacant land required for future widening of roads, especially in urban or suburban areas.

The Road Board suggests that before sending in applications, conferences should be held between surveyors of counties and of local districts for the purpose of selecting projects which require first consideration. According to U. S. Consul Albert Halstead, Birmingham, the British Road Improvement Association expects to give its aid in the preparation and submission of schemes for road improvement.

Personals.

Mr. E. P. Shannon has been appointed Assistant to the President of the Oregon Trunk Ry., Oregon Electric Ry. and the United Rys.

Mr. A. H. Van Cleve, M. Am. Soc. C. E., of Niagara Falls, N. Y., has been appointed Chief Engineer of the City of London, Ontario.

Mr. C. A. Brandt has been appointed Mechanical Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Ry. and the Peoria & Eastern Ry., with headquarters at Indianapolis, Ind.

Mr. L. B. Wickersham, General Manager of the United Rys. Co., has been appointed Chief Engineer of the Oregon Electric Ry. Co. Mr. C. A. Coolidge succeeds him as General Manager of the United Rys.

Mr. C. W. Galloway, General Superintendent of Transportation of the Baltimore & Ohio Southwestern R. R., at Baltimore, Md., has been appointed General Superintendent to succeed Mr. W. H. Brimson, resigned.

Mr. Timothy E. Byrnes, Vice-President of the New York, New Haven & Hartford R. R., will succeed Mr. Lucius Tuttle, whose resignation was noted in our issue of Sept. 15, as President of the Boston & Maine R. R.

Mr. Earle Jackson Banta, M. Am. Soc. M. E., has resigned his position as Chief Engineer of the Ohio Steam Shovel & Dredge Co., Cincinnati, Ohio, to take a similar position with the Vulcan Steam Shovel Co., of Toledo, Ohio.

Mr. P. E. Stevens, Assoc. M. Am. Soc. C. E., has resigned his position as Assistant Engineer in the Bridge Department of the Great Northern Ry. to take a position with the firm of Butler Bros., general contractors, of St. Paul, Minn.

Mr. F. C. Kyte, Chief Engineer of the Pine Bluff & Northern Ry. at Carlisle, Ark., has resigned that position and will sail from New York City, Oct. 5, for Porto Velho, Rio Madeira, Brazil, to enter the service of the Madeira-Mamore Ry.

Mr. Robert C. Winters has resigned his position as Assistant Superintendent of Buildings, Borough of the Bronx, New York City, on the ground that there was no work for him to do in that position. The position carried a salary of $4,000 per annum.

Mr. Jerome Cochran, Jun. Am. Soc. C. E., who recently practiced as a consulting engineer at Houston, Tex., has become Designing Engineer of the Corrugated Bar Co., of St. Louis, with offices in the National Bank of Commerce Building, St. Louis, Mo.

Mr. Rupert K. Stockwell, Jun. Am. Soc. M. E., has resigned his position as Construction Engineer with the United States Smelting, Refining & Mining Co., of Salt Lake City, Utah, and has become Assistant General Superintendent for the Alpha Portland Cement Co., at Easton, Pa.

Mr. J. C. Stevens, Assoc. M. Am. Soc. C. E., resigned last July his position as District Engineer, U. S. Geological Survey, at Portland, Ore., in charge of water resources work in the Pacific Northwest. He has recently opened an office for the practice of hydraulic engineering at 509 Beck Bldg., Portland, Ore.

Mr. Elwood Mead, M. Am. Soc. C. E., M. Inst. C. E., Chairman Water Supply Commission of the State of Victoria, Australia, is now spending a number of weeks in this country. Mr. Mead is accompanied by Hon. Hugh McKenzie, Victorian Minister for Lands. The two constitute a Land Settlement Commission, appointed by the State of Victoria to visit England and the United States for the purpose of securing settlers on land owned by the State. It is hoped that settlers experienced in irrigation can be induced to go to Australia. The State, as we understand it, is not only putting water on relatively small holdings of land, but is also building houses for the farmers. Many of our readers will remember Mr. Mead as having been State Engineer of Wyoming, and later and until comparatively recent years, Chief of Irrigation and Drainage Investigations, U. S. Office of Experiment Stations, Department of Agriculture. Mr. Mead will also be remembered by many as a lecturer on Irrigation Institutions at the University of California for a number of years. While in this country Mr. Mead may be addressed at the Auditorium Annex, Chicago, until Sept. 24, and at the Brown Palace Hotel, San Francisco, from that time until the middle of October. Before he leaves the country, he and the other members of his commission will visit some of the irrigated sections of the United States. He will sail for Australia early in November.

Obituary.

R. J. Kinler, Manager of the Temiskaming & Hudson Bay mine near Cobalt, Ont., was killed by a fall, Sept. 9, while superintending the erection of a new mill at the mine.

Frederick Meriam Wheeler, M. Am. Soc. M. E., died Sept. 15 at his summer home in Westhampton, Long Island, aged 62 years. Mr. Wheeler was born in Brooklyn, N. Y., was a graduate of Summit Academy, Summit, N. J., and subsequently attended the Brooklyn Polytechnic Institute. He studied mechanical engineering under Henry J. Davidson, of New York City, for five years and for 34 years was associated with the George F. Blake Manufacturing Co. He became a director and secretary of this company and later became a director of the International Steam Pump Co. He was the inventor of the Wheeler surface condenser and was associated at the time of his death with the Wheeler Condenser & Engineering Co. at the New York office. Mr. Wheeler was a member of the Society of Naval Architects and Marine Engineers, the American Society of Naval Engineers and of the Engineers' Club of New York City. At the Columbian Exposition he was a member of the advisory council of the Engineering Congress. He was married in 1876 to Miss Florence Willmer, who, with his two sons and two daughters, survives him at their home in Montclair, N. J.

Engineering Societies.

COMING MEETINGS.

NATIONAL IRRIGATION CONGRESS.
Sept. 26-30. Annual meeting at Pueblo, Colo. Secy., Arthur Hooker, Pueblo, Colo.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 10-14. Annual convention at Atlantic City, N. J. Secy., H. C. Donecker, 29 West 39th St., New York City.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 11-14. Annual convention at Erie, Pa. Secy., A. P. Folwell, 239 West 39th St., New York City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 11-13. Annual meeting at Richmond, Va. Secy., C. C. Rosenberg, Bethlehem, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 13-15. Annual meeting at Chicago, Ill. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 18-20. Annual convention at Denver, Colo. Secy., C. A. Lichtty, Chicago & Northwestern Ry., Chicago, Ill.

AMERICAN GAS INSTITUTE.
Oct. 19-21. Annual meeting at New York City. Secy., A. B. Beadle, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Oct. 21-Nov. 15. Canal Zone meeting. Secy., R. W. Raymond, 29 West 39th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.
Oct. 24. Annual convention at Baltimore, Md. Secy., P. S. Millar, 29 West 39th St., New York City.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 15. Annual meeting at Washington, D. C. Secy., Wm. H. Connelly, Interstate Commerce Commission, Washington, D. C.

AMERICAN RAILWAY ASSOCIATION.
Nov. 16. Semi-annual meeting at St. Louis, Mo. Secy., W. F. Allen, 24 Park Pl., New York City.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 17-18. Annual meeting at New York City. Secy., W. J. Baxter, 29 West 39th St., New York City.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Nov. 17-19. Annual convention at Boston, Mass. Secy., James C. Monaghan, 20 West 44th St., New York City.

NATIONAL MUNICIPAL LEAGUE.—The 16th annual meeting will be held at Buffalo, N. Y., Nov. 14-18. The secretary is Mr. Clinton R. Woodruff, 121 South Broad St., Philadelphia, Pa.

NEW YORK RAILROAD CLUB.—At the regular meeting of Sept. 16 a paper on "The Testing Department of a Railroad" was presented by Mr. B. S. Hinckley, Engineer of Tests, New York, New Haven & Hartford R. R.

NATIONAL GOOD ROADS CONVENTION.—Among the papers listed in the preliminary program of the third annual convention at St. Louis, Mo., Sept. 26-30, are the following: "Roads for Modern Traffic in the South," J. T. Bullen, Montgomery, Ala.; "Paved Roads," A. N. Johnson, State Highway Engineer, Springfield, Ill.; "Modern Road Construction in the United States," Walter W. Crosby, Chief Engineer, Maryland Roads Commission, Baltimore, Md.; "Continuous and Systematic Road Maintenance," S. Percy Hooker, Chairman, New York State Highway Commission, Albany, N. Y.; "City Streets and Boulevards," James C. Travilla, Street Commissioner of St. Louis, Mo.; "Modern Surface Treatment of Various Roads," Charles W. Ross, Street Commissioner, Newton, Mass.; "Town and Lateral Roads," Frank D. Lyon, Deputy State Highway Commissioner of New York; "State Roads to Meet Modern Traffic Conditions," Harold Parker, Member Massachusetts Highway Commission, Clinton, Mass.; "Park Roads," John R. Rablin, Chief Engineer, Metropolitan Park Commission, Boston, Mass.; "Dustless Roads of California," Austin B. Fletcher, Engineer, Highway Commission of San Diego County, Cal.; "Dustless Roads of Europe," Arthur H. Blanchard, Deputy Engineer, State Board of Public Roads of Rhode Island, Providence, R. I.